

EXPERIMENTAL INQUIRIES

INTO THE

FORMATION

OF THE

RED PARTICLES OF THE BLOOD.

BRITISH MUSEUM



NO. 1

OF THE

BRITISH MUSEUM

2

Experimental Inquiries :

PART THE THIRD.

CONTAINING A

DESCRIPTION

OF THE

RED PARTICLES OF THE BLOOD

IN THE

HUMAN SUBJECT and in other ANIMALS;

WITH

An Account of the Structure and Offices of
the LYMPHATIC GLANDS, of the THYMUS
GLAND, and of the SPLEEN:

BEING

The remaining Part of the OBSERVATIONS and
EXPERIMENTS of the late Mr. WILLIAM
HEWSON, F. R. S. and Teacher of Anatomy.

By MAGNUS FALCONAR,

SURGEON, AND TEACHER OF ANATOMY.

*Nullius addictus jurare in verba magistri,
Et verum et veri cupio cognoscere causas.*

Hor.

LONDON:

Printed for T. LONGMAN, No. 39. Pater-noster-Row.

MDCCLXXVII.

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the Lymphatic Glands and Thymus

Glands.



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Experiment of the late MR. WILLIAM

NEWSON, F.R.S. and Teacher of Anatomy.

MAGNUS FALCONER

Surgeon and Teacher of Anatomy.

Printed by J. G. & J. H. in the Strand.

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MDCCLXXVII.

TO
WILLIAM BROMFIELD, Esq;
SURGEON TO HER MAJESTY,
AND TO ST. GEORGE'S HOSPITAL;
AND TO
PERCIVAL POTT, Esq; F. R. S.
AND
SURGEON TO ST. BARTHOLOMEW'S HOSPITAL,

THE FOLLOWING SHEETS
ARE MOST HUMBLY INSCRIBED,
AS A TRIBUTE OF GRATITUDE AND RESPECT;

BY
THEIR MUCH OBLIGED, AND
VERY HUMBLE SERVANT,

THE EDITOR.

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P R E F A C E.

THE following sheets comprise the remaining part of the discoveries and experiments of my late friend Mr. WILLIAM HEWSON, in whose death the Public sustained an almost irreparable loss; the loss of a Genius, whose superior abilities in his profession, rendered him eminently conspicuous among his contemporaries, and I have no doubt, will transmit his fame to posterity, enrolled among the highest names

of antiquity. But to the men of science of this age, his talents require no commendation from my pen.

UNFORTUNATELY for the world, his death prevented him from completing the work he had begun: the first Chapter of this Treatise only was written by him, and read in the Royal Society, June 17th and 24th, 1773; which was afterwards published in the Second Part of the sixty-third volume of the Philosophical Transactions; and it is much to be lamented, that among his papers we have not found the smallest note upon the subject of the other four Chapters.

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Chapters. But a three years acquaintance, during the greatest part of which the strictest intimacy and friendship subsisted between us, afforded me numberless opportunities of discoursing with him upon this subject, and of making myself perfectly acquainted with his ideas; besides which, as I had the advantage of assisting him in other anatomical pursuits, it was frequently my good fortune to make and repeat many of the experiments; by which means I became not only better acquainted with the doctrine, but also perfectly confirmed in my knowledge of its truth.

As

AND I

As far as I can recollect, I have recited the experiments in the order they were made by Mr. HEWSON; but lest I might err, or not represent facts in their true state, I have repeated all the experiments frequently since his death, and have written them circumstantially as they appeared to me. But to make these experiments with the attention and circumspection necessary upon so curious a subject, requires more time than my other employments would permit, on which account I have been obliged to defer the publication of them till this time, when I hope their greater accuracy will in some measure compensate for my delay.

I HAVE

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I HAVE chosen to publish them under the form of Chapters and Sections, for the sake of more precision for those who are not much conversant in anatomy; at the same time, I flatter myself, this method will not be wholly unacceptable to those who have made that branch of natural philosophy their particular study: for as the facts are numerous, by this method they will be referred to with much greater facility, and the propriety of the inferences will be judged of the more readily.

To such Gentlemen as are not well acquainted with anatomy, the subject, from the quantity of new matter

matter it contains, may appear obscure; but as this is a doctrine in which not only the medical part of the world, but Philosophers in general, are much interested, we most earnestly intreat them to suspend their judgment till they have deliberately considered all the facts. The inductions will then, I presume, be thought just.

As it is the ultimate end of Philosophy to investigate truth, so it must afford the greatest pleasure to generous minds to embrace it, in whatever form they find it. The Remarks and Criticisms of such, I shall

P R E F A C E.

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I shall esteem the greatest obligations.

Some there may be, who having early imbibed prejudices, will find it very difficult to shake them off.

Others may be very unwilling to believe, that they have erred both in opinion and practice, all the preceding part of their lives. I shall at all times esteem it a happiness and an honour to remove the doubts of these Gentlemen, not so much from a wish to persuade by argument, as to convince by demonstration:

AND as many Gentlemen who are not possessed of glasses, may be desirous

desirous of seeing the Experiments
upon the Blood, I shall at all times
be happy in shewing them to such
Gentlemen as will do me the favour
of calling upon me.

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ERRATA.

Page 14. line 13. *for shewed read shewn.*

47. — 1. Note, *after inveni insert a comma (,).*

3. — *for ligatio read ligatum.*

16. — *for vasse read vase.*

48. — *ult. — for vasculorum glandula read*
vasorum glandulæ.

56. — 7. *for and by far read and in by far.*

66. — 4. Note, *for cinerum read cinereum Mal-*
pighius, diaphanum Nuckius,
album Morgagnius.

78. — 1. — *for his read is.*

EXPERIMENTAL INQUIRIES

INTO THE

FORMATION

OF THE

RED PARTICLES OF THE BLOOD.

CHAP. I.

*On the figure and composition of the Red
Particles of the Blood, commonly call-
ed, the Red Globules.*

THE red particles of blood in the
human subject have, since the time
of Leeuwenhoeck, been so generally al-
lowed to be spherical, that in almost all

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books of phyfiology they are denominated *red globules*. A few authors, however, have, at different times, doubted whether they were spheres, and amongst the rest Father de la Torr , whose curious observations, together with his glasses, were presented to the Royal Society, anno 1766.

It is a curious and important fact, that these particles are found so generally through the animal kingdom, that is, they are found in the human species, in all quadrupeds, in all birds, in all amphibious animals, and in all fish, in which animals they are red, and colour the blood.

THE blood even of insects contains particles similar in shape to those of the blood

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blood of more perfect animals, but differing in colour.

IN water insects, as the lobster and shrimp, these particles are white, in some land insects, as the caterpillar and grasshopper, they appear of a faint green when in the vessels, as I am persuaded from experiments. I have seen them in an insect no bigger than a pin's head, and suspect they exist almost universally through the animal kingdom.

WHAT is so generally extended through the creation, must be of great importance in animal œconomy; and highly deserving the attention of every inquirer into the works of nature. This subject becomes the more interesting, so much reasoning in the theory of medicine being built on the properties of those particles.

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IT is by the microscope alone, that we can discover these particles; and as some dexterity and practice is required in the use of that instrument, there have not been wanting men of character and ingenuity, who, having been unsuccessful in their own experiments, have questioned the validity of those made more fortunately by others. Some have gone so far as to assert, that no credit can be given to microscopes; that they deceive us, by representing objects different from what they really are.

THESE assertions, though not entirely without foundation, when we speak of one sort of microscopes, are very unjustly applied to them all. In compound microscopes, when the object is viewed through two, or more glasses, if these glasses be not well adapted to the focus of each other, the figure of the object may

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may be distorted; but no such circumstance takes place when we view an object through a single lens. All who use spectacles agree, that the figures of objects appear the same through them, as they do to the naked eye. And as the single microscope has, like the spectacle; but one lens between the eye and the object, there is no reason to suppose the one can deceive us more than the other. The compound having a larger field, is more pleasant than the single microscope for many purposes; but the single should be always preferred by those who wish to ascertain the figures of minute bodies. It was this instrument, supported on a scroll, as delineated by Mr. Baker, (*Microscope made easy*, Plate 2. Chap. ix.) that has been used in these experiments, and almost all the observations were made with *lenses*, as they are prepared by some

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of our more skilful workmen in London, One observation only, was made by means of those globules, made of glass, which the ingenious Father de la Torr  presented to the Royal Society, and which they were so obliging to lend to me. Of these globules, two only were fit for use, when they came to my hands; *viz.* that which, according to Father de la Torr , magnifies the diameter of the object 640 times, and that which magnifies 1280 times. The *lenses* of the greatest magnifying power made in London, are those of $\frac{1}{30}$ of an inch focus; which, even allowing eight inches to be the focal distance of the naked eye, magnifies the diameter of the object only 400 times; a power much inferior to what may be obtained by globules, and particularly by that globule, which, according to Father de la Torr , magnifies the diameter

meter

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meter 1280 times; and this globule I have used in some of these experiments. But our *lenses*, though inferior in magnifying power to these globules, are much superior in distinctness. The globules are full of clouds made by the smoke of the lamp used in preparing them, and the object can be seen only through the transparent parts of the globules; which makes it difficult to get a satisfactory view of it: this, with the trouble of adapting the object to the focus of the glass, made me prefer our own *lenses* for all the experiments mentioned in these sheets, except one; and it is but doing justice to the ingenious gentleman above mentioned, to acknowledge, that the greater power of his glasses was found, in that experiment, more than to compensate for their want of distinctness.

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THESE *particles of the blood*, improperly called *Globules*, are in reality *flat bodies*; Leeuwenhoeck and others have allowed, that in fish, and in the *amphibia*, they are flat and elliptical, but in the human subject and in quadrupeds, almost all microscopical observers have agreed in their being spherical. When we consider how many ingenious persons have been employed in examining the blood with the best microscopes, it will appear wonderful that the figure of these particles should have been mistaken; but our wonder will be lessened, when we consider how many obvious things are overlooked, till our attention is very particularly directed to them: and besides the blood in the human subject, and in quadrupeds, is so full of these particles, that it is with great difficulty we can see them separate, unless we find out a
method

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method of diluting the blood. It is to such a discovery, that I attribute my success in this inquiry; for having examined the blood as it flows from the vessels of the human body, it appeared a confused mass, notwithstanding I spread it thin on a glass, or a piece of talk. It then occurred to me to dilute it, but not with water, for this I knew dissolved the particles, but with *serum*, in which they remained undissolved. By the *serum* I could dilute it to any degree, and therefore could view the particles distinct from each other; and in these experiments I found, that these particles of the blood were as flat as a guinea. I likewise observed, that they had a dark spot in the middle, which Father de la Torr  took for a hole; but upon a careful examination, I found it was not a perforation, and therefore that they were not annular. I next made

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experiments by mixing these particles with a variety of other fluids, and examined them in many different animals, and the result of these experiments was, that their size is different in different animals; as is seen in Plate I. where they are represented of the size they appeared to my eye, when viewed through a lens of $\frac{1}{23}$ of an inch focus; which, allowing eight inches to be the focal distance of the naked eye, magnifies the diameter 184 times.

It may not be improper to observe here, that the accurate Leeuwenhoeck, not having diluted the human blood or that of quadrupeds, so as to see these particles separate from each other, was thence not qualified to describe them from his own observation, as he has done those of fish and of frogs, and suspecting a round figure

On the Red Particles of the Blood. 11

figure was more fit for circulating in our vessels, was thence led to suppose these particles spherical in the human subject. But I shall hereafter be able to shew from his own words, that it is not his observations, but his speculative opinions, or his theory, that differs from what I have discovered by these experiments.

IN Plate I. it appears, that of all the animals which I have examined, the particles are larger in the fish called a skate; next to a skate they are larger in a frog and a viper, and other animals of this class: they are somewhat smaller in the common fish, as the salmon, cod, and eel. In birds they are smaller than in fish; in the human subject smaller than in birds; and in some quadrupeds still smaller than in the human subject. Leeuwenhoeck, speaking of their size, says,
he

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he is confident the red particles of the blood are no larger in a whale, than in the smallest fish *. And others have since his time said, they are of the same size in all animals; but it is evident from comparing their size as delineated in the above-mentioned plate, that it differs considerably, and that they are not larger in the largest animals; for we find that in an ox they are not so large as in a man, and so far are they from being larger in the whale than in the small fish, it appears probable, from comparing their size, as delineated Plate I, N^o 2, from a porpoise which belongs to the same genus as the whale, that they are smaller in those animals than in fish; neither is their size inversely as in the size of the animal, for they are as large in an ox, as in a mouse. The difference in their size

* Conf. Arcan. Nat. p. 220.

size therefore depends on some other circumstance than a difference in the size of the animal.

As to their shape, I have already mentioned, that they are flat in all animals, even in the human subject, of which any one may be convinced by repeating the following experiments.

EXPERIMENT I.

TAKE a small quantity of the *serum* of human blood, and shake a piece of the *crassamentum* in it till it is coloured a little with the red particles; then with a soft hair pencil spread a little of it on a piece of thin glass, and place this glass in the microscope, in such a manner as not to be quite horizontal, but higher at one end than the other, by which means the

serum

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serum will flow from the higher extremity to the lower; and as it flows, some of the particles will be found to swim on their flat sides, and will appear to have a dark spot in their middle; others will turn over from one side to the other, as they roll down the glass. No person who sees them turn over, can doubt of their being flat; he will see them, in turning, have all the phases that a flat body has; first, he will see them on one side, then rise gradually on the edge, and turn over to the other side. I have in this way shewed their figure to a number of curious persons, and particularly to many students of anatomy, who have attended Lectures in London within the last six years. If instead of *serum* the particles should be diluted with water, containing rather more salt than *serum* does, or if instead of human blood, that of an animal with larger

On the Red Particles of the Blood. 15

larger particles be used, then they will sometimes be seen not only flat, but a little bended, like a crooked piece of money.

THESE experiments not only prove, that the particles of the blood are flat, and not globular, but likewise, by proving that they are flat, they shew that they are not fluid, as they are commonly believed to be; but, on the contrary, are solid, because every fluid swimming in another which is in larger quantity, if it be not soluble in that other fluid, becomes globular. This is the case when a small quantity of oil is mixed with a larger quantity of water, or if a small quantity of water be mixed with a large one of oil, then the water appears globular; and as these particles are not globular but flat, they must be solid, a circumstance that

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that will appear still more evident from future experiments.

IT is necessary to remark, that in a few minutes after the particles are spread out on a glass, they run in clusters, and stick to each other, and then they appear confused.

WHEN one of these particles is attentively examined, while separate from the rest, it appears, as it lies on its flat side, to have a dark spot in the middle, and round that dark spot it is more transparent. This dark spot was believed to be a perforation, or the particle was supposed to be a hollow ring, by the ingenious Father de la Torre. But I find from a great number of experiments, that the dark spot is a solid particle contained in a flat vesicle, whose middle only it fills,

On the Red Particles of the Blood. 17

fills, and whose edges are hollow, and either empty or filled with a subtile fluid. This will be evident to every one who will carefully make the following experiments.

EXPERIMENT II.

TAKE a drop of the blood of an animal that has large particles, as a frog, a fish, or what is still better, of a toad; put this blood on a thin piece of glass, as used in the former experiment, and add to it some water, first one drop, then a second, and a third, and so on, gradually increasing the quantity; and in proportion as water is added, the figure of the particle will be changed from a flat to a spherical shape. When much water is added, the vesicle will by degrees become thinner and more transparent, and

C

will

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will at last be dissolved. When the vesicle has thus assumed a spherical shape, it will roll down the glass stage smoothly, without those phases which it had when turning over whilst it was flat; and as it now rolls in its spherical shape, the solid middle particle can be distinctly seen to fall from side to side in the hollow vesicle, like a pea in a bladder. Sometimes indeed, instead of falling from side to side, the solid middle particle is seen to stick to one part of the vesicle; and in proportion as the vesicle, instead of being flat, assumes a spherical shape, its longest diameter is shortened, as might be expected on the supposition of its being hollow and flat.

AFTER this experiment has been made on the blood of such animals as have large vesicles, it may be made on human blood,

blood, where the water will be found to have the same effect; the vesicles will become spherical, the diameters of these spheres will be less, than the largest diameter of the vesicle in its flat state.

It is remarkable, that more water is in general required to produce this change on the vesicles of the human blood, than on those of frogs, or other amphibious animals; and those of the *amphibia* require still more than those of fish, for the substance of these vesicles being thicker, and more coloured in man and in quadrupeds, than in the *amphibia*, is therefore later in being dissolved in water; and being thinnest in fish, it thence most readily dissolves. Those who are desirous of repeating these experiments, had best begin with the blood of toads and frogs, whose vesicles are large, and remain

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some time without dissolving in the water; (when that is used with the above-mentioned precaution) by which means any one accustomed to microscopical experiments may readily be satisfied of these curious circumstances.

FROM the greater thickness of the vesicles in the human subject, and from their being less transparent when made spherical by the addition of water, and likewise from their being so much smaller than those of fish or frogs; it is more difficult to get a sight of the middle particles, rolling from side to side in the vesicle *, which are become round; but with a strong light, and a deep magnifier, I have distinctly seen it in the

* These experiments were all made with day-light, in clear weather.

human

On the Red Particles of the Blood. 21

human subject, as well as in the frog, toad, and skate.

SINCE water makes these particles round, and makes the dark spot in their middle disappear, it is evident, the red particles of the human blood are not perforated; but that dark spot is owing to something else than a hole, and this is likewise confirmed, by observing, that although the particle does, in an obscure glass, appear only to have a dark spot, which might be supposed to have a hole, yet with a very transparent *lens*, and a good light, after diluting the blood with *serum*, that middle part can be distinctly seen, to be only of a deeper red than the rest of the vesicle, and thence appears darker.

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IN these experiments, made by adding water to the blood, the middle particles appear to be less easily soluble in water, than the flat vesicle which contains them: so that a little time after the proper quantity of water has been added, the flat vesicles disappear, leaving their middle particles, which seem to be globular, and very small,

THAT these red vesicles of the blood, although flat, are not perforated, is evident, likewise, from a curious appearance which I have repeatedly observed in blood that has been kept three days in the summer season, until it was beginning to putrify; the vesicles of this blood being diluted with *serum*, and examined with a *lens* $\frac{1}{10}$ of an inch focus, (but more particularly when examined with M. de la Torre's glass, which by
his

his computation magnifies the diameter 1280 times) were found to have become spherical, the diameter of these spheres were less than their largest diameter when flat, and their external surface was corrugated in such a manner, as to make them appear like small mulberries.

I HAVE seen the same appearance on mixing *serum* (that had been kept three days in a warm place, and smelt putrid) with fresh drawn human blood: the vesicle assumed this globular and mulberry-like appearance. In these experiments on human blood beginning to putrify, I have likewise observed some of these vesicles break into pieces, without becoming spherical, and I have distinctly perceived the black spot in the centre fissured through its middle,

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another proof that it is not a perforation,

IN the blood of an eel, which was beginning to putrify, I have seen the vesicle split, and open, and the particle in its centre come out of the fissure. As the putrefaction advances, these vesicles which had become rough spheres, or like mulberries, and those which had been merely fissured, each break down into smaller pieces: M. de la Torre seems to think they have joints, and break regularly into seven parts; and Leeuwenhoeck suspected these globules, (*as he called them*) were constantly made of six lesser globules.

BUT from observations I am convinced there is nothing regular, or constant,

stant, in the number of pieces into which they break: I have seen them fall into six, seven, eight, or more pieces, by putrefaction; for putrefaction breaks them down in the manner it destroys other animal solids. I need hardly take notice, that the small pieces into which the vesicles break, are equally red as the vesicle itself. The theory of the red globules being composed of six serous ones, compacted together, and the serous globules of six of lymph, has not the least foundation, and is entirely overthrown by the simple experiment of mixing the blood with six, or thirty-six, times its quantity of water; for the water dissolving the globules, ought to reduce them to yellow *serum*, or colourless lymph*; but it does not, on the contrary it is coloured red by these

* See Gaubii Pathologia.

particles,

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particles, even when used in much greater proportion than thirty-six parts of water to one of blood.

THESE red vesicles of the blood have not only been commonly supposed globular and fluid, but they have with equal injustice been imagined to be oily, and more inflammable than the rest of the blood. That they are not oily, is evident from their so readily dissolving in water, and that they are not more inflammable than the rest of the blood, is manifest, by burning them after they are separated from the rest of the blood; which separation may be effected, by shaking the *crassamentum* in the *serum*, so as to diffuse the particles through it, and then by pouring off the *serum* when they have subsided in it: I have separated them in this manner, and compared their inflammability

mability with that of inspissated *serum*, and of dried coagulable lymph, and have not observed them more inflammable than the *serum*, or the lymph; nor do they melt like oil as some have suspected, but burn like a piece of horn. Some authors who have written on the figure of these vesicles in quadrupeds, and in the human subject, have expatiated on the great advantage of their (supposed) spherical shape, in order for their more easy circulation; as it is probable that no form is preferable to a spherical one for easy motion; but as these vesicles are evidently not spherical, but flat in all animals, we must believe that nature has some good purpose to answer by making them of that form,

It has been objected, that notwithstanding they appear flat out of the body,

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they may possibly be globular in the body while circulating; and it has been said, that it is almost inconceivable that so many ingenious men should at different times have viewed them through a microscope, and have concluded them spherical, if they be really flat. But however that may have happened, it is a fact, that they are as flat in the body as out of it. Of this I am convinced, by having repeatedly observed them, whilst circulating in the small vessels, between the toes of a frog, both in the solar microscope, and the more simple one abovementioned. I have seen them with their sides parallel, like a number of coins, laid one against another.

I HAVE likewise in that animal where they are elliptical, seen them move with one end foremost, and sometimes

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with

with an edge turned towards the eye. I have moreover seen them when entering a small vessel, strike upon the angle between it and the larger trunk, and turn over with the same variety of phases, that they have when turning over upon a piece of glass.

UPON this occasion, I may remark, that it has been said by some microscopical observers, that in passing through very small vessels, they seem to alter their shape and to be lengthened.

THIS conclusion I suspect has taken its rise from the observer having seen them with their edge turned towards his eye, in which case they would appear long and small, as if lengthened by compression, especially to one who sets out with the notion of their being globular.

I have

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I have seen them, in blood vessels which would admit only single vesicles, move with difficulty, as if streightened for room, but never saw them altered in their shape by the action of the vessels.

If then they really be not globular, but flat, and if water so readily alters their shape, whence is it, that the *serum* has the property of preserving them in that form, which seems so necessary? because it is so general through the animal creation.

IT is principally by the salts of the *serum*, that this effect is produced, as is proved by adding a small quantity of any neutral salt to water, when the water is no longer capable of dissolving those particles, nor does it alter their shape when

when the salt is used in a certain proportion.

EXPERIMENT III.

IF a saturated solution of any of the common neutral salts be mixed with fresh blood, and the globules (as they have been called, but which for the future, I shall call flat vesicles) be then examined in a microscope, the salt will be found to have contracted or shrivelled the vesicles, so that they appear quite solid, the vesicular substance being closely applied all round the central piece. In proportion as the solution of salt is diluted with water, it has less effect, and when diluted with six, eight, ten, or twelve times its quantity of water, it produces no change in the figure of the vesicles,

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vesicles, whose flat shape can then be seen, even more distinctly than when mixed with *serum* itself.

The neutral salts, which when diluted with water, have been observed to have the effects above described, are Glauber's salt, Epsom salt, formed of the volatile alkali and the vitriolic acid, common nitre, cubic nitre, a salt made with the volatile alkali and the nitrous acid, as well as the salts made with the nitrous acid and magnesia, or with the nitrous acid and chalk, and also common salt, digestive salt of Sylvius, and a salt made with vinegar and the fossil alkali. These experiments were sufficient to convince me, that this property was very general among those salts which consist of acid and alkali, and therefore it seemed unnecessary to prosecute

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secute this inquiry further *. But acids and alkalies have different effects on these vesicles from what neutral salts have.

The fixed vegetable alkali, and the volatile alkali, were tried in a pretty strong solution, and found to corrugate the vesicles, and in proportion as they were diluted, their effects became similar to water alone: but it is not easy to find the point of strength where the vesicles would remain unaltered in the solution. And here we may observe, that since these vesicles are found to dissolve so readily in water, and not to be dissolved

* These experiments were made by putting one drop of the saturated solution of the salt into a tea cup, and then adding distilled water by a few drops at a time, and to this mixture, the *serum* of the blood highly tinged with the red vesicles was added.

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in these solutions of alkali, it is a strong argument against their being oily, or saponaceous, as they have been suspected.

THE effect of acids are very different. I have tried the vitriolic, nitrous, muriatic, distilled vinegar, and the acid of phosphorus; these, when much diluted, have the same effect as water in making the vesicle spherical, and in proportion as they are less diluted, they dissolve the vesicles, without making them spherical as water does. I never could find any point of dilution, where the acids, like the neutral salts, produced no change on the figure of the vesicles. This experiment is the more to be attended to, as these vesicles have been supposed to be oily and saponaceous, which is improbable, since they dissolve more readily in acids than in alkalies.

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SALTS made with earth of alum, and any of the acids, always corrugate those vesicles, unless they be much diluted, when their effects are similar to those of water alone; that is, they make the vesicle assume a spherical shape. I could not discover any point of strength in these solutions, where the particles would remain in them, without being changed in their shape.

THE same was observed of spirits of wine; some of the metalline salts, as copperas, sublimate and Roman vitriol, were tried, and when much diluted, their effects were not different from those of water; but in proportion as the solution was stronger, they corrugated the vesicles more and more.

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URINE when containing much of its salts, has effects similar to the *serum*, but in proportion as it is weaker, its effects are more like those of water.

THE use therefore of those salts which enter into the composition of the blood, is probably to preserve the red vesicles in their flat form, for we must suppose some advantages attend that shape, since nature has made use of it so generally in the blood of different animals. And as both a very strong solution of neutral salts, and a very diluted one, alters the shape of the vesicles, it is probable, nature has limited the proportions of the water, and the salts, in our blood.

A DEGREE of latitude in these proportions, however, seems to be admitted,
for

for I observed the vesicles equally unchanged, when mixed with a solution of salts, consisting of eight drops of water to one of the saturated solution. And when added to a mixture of fifteen drops of water, to one of the same solution: not only the neutral salts in the blood are capable of preventing the *serum* from dissolving the vesicles, but the mucilage, or lymph, with which the *serum* is so much impregnated, seems to contribute to the same effect.

WHEN the vesicles have been made spherical by being mixed with water, if a small quantity of a pretty strong solution of a neutral salt be added, they are immediately shrivelled; a few of them recover their former flat shape, but the greatest part are contracted irregularly into small spheres. When these vesicles

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thus recover their shape, after having been a short time mixed with water, they are generally more transparent, and appear thinner, a part of their substance having been dissolved in water; and thence it is more easy to distinguish the little solid particle which is contained in them. By this experiment I have had the pleasure of convincing many curious persons, of the composition of this part of the blood, who were not quite satisfied from some of the other experiments.

I HAVE mentioned above, and shewn in Plate I. that these vesicles are of different sizes in different animals. I have likewise observed, that they are not all of the same size in the same animal, some being a little larger than others, and some dissolve

dissolve in water more readily than others.

IN the same species of animals, they even differ in size in the different periods of life. In a chicken, on the sixth day of incubation, I found them larger than in a full-grown hen, as it is represented in the Plate, and I have found them larger in the blood of a very young viper, than in that of its mother, out of whose belly it was taken. I have not however been convinced from experiments, that there is any difference in size between those of a child at its birth, and those of an adult person.

IN the blood of some insects, the vesicles are not red, but white, as may

easily be observed in a lobster, (which Linnæus calls an insect) one of whose legs being cut off, a quantity of a clear sanies flows from it; this after being some time exposed to the air jellies, but less firmly than the blood of more perfect animals. When it is jellied, it is found to have several white filaments; these are principally the vesicles con-creted, as I am persuaded from the following experiment.

EXPERIMENT III.

If one of the legs of a lobster be cut off, and a little of the blood be caught upon a flat glass, and instantly applied to the microscope, it is seen to contain flat vesicles, that are circular, like those of
the

the common fish, and have each of them a lesser particle in their centre, as those of other animals. But there is a curious change produced in their shape, by being exposed to the air, for soon after they are received on the glass, they are corrugated, or from a flat shape are changed into irregular spheres, as is represented in Plate I. This change takes place so rapidly, that it requires great expedition to apply them to the microscope soon enough to observe it.

I HAVE observed the fanies or blood of a shrimp, by cutting off its tail, and found vesicles in it similar to those of the lobster; which have been a short time exposed to the air. But I never could apply the blood, so as to see them in their flat form; but since they change by exposition

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position to the air, I conjecture, that like them they are flat in the blood vessels, but being more susceptible of changes from the contact of air, they were corrugated before I could get them applied to the microscope.

THE ingenious Leeuwenhoeck has observed, that in the blood of a grasshopper, its vesicles or globules, as he calls them, are green; I have seen the same circumstance in the white caterpillar, whose *serum* appeared green when in its vessels, but when let out from this animal, or from a grasshopper, the colour cannot be distinguished.

THE smallest animal in which I have discerned these vesicles, is an insect no bigger than a pin's head, that is seen almost

almost constantly in the river water which we have in London. This insect, which is a species of the monocolus, being put into a concave glass with a little water, and the rays of the sun being made to pass through it, the heart may be seen to beat, and the transparent blood or sanies found to have a few vesicles, which appear to move one after the other; being made visible though transparent, by the light passing in such a manner, as to be refracted by them.

SINCE so small an animal as this, has these curious vesicles, equally as the larger and more perfect animals, is it not probable, that they are diffused through the whole animal creation? And what is found so generally amongst animals, must be of great use in their œconomy,

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As these curious vesicles therefore are so universally found amongst all animals, and as their structure is in all animals similar, we are naturally led to conclude, that parts so complicated cannot be made by a mere mechanical agitation of the chyle in the blood vessels, or lungs; but that nature has set apart certain organs in the body for their formation. And which we shall next inquire into,

CHAP.



C H A P. II.

On the Structure of the Lymphatic Glands.

THESE Glands, which by Anatomists are called the *Lymphatic Glands*, and vulgarly known by the name of Waxen Kernels, since the discovery of the Lymphatic vessels by Rudbec and Bartholine (*anno* 1651-2.), have been properly considered as appendages to the Lymphatic System; and though many excellent anatomists since that period, have employed themselves with great

great assiduity, and made many curious experiments with a view to complete the discovery of this important subject; yet the Lymphatic Glands seem to have derived fewer advantages from this spirit of inquiry, than the other parts of the system; their structure and office being unknown, except what relates to their gross anatomy, and even in that respect the best anatomists are not well agreed. Some suppose, that each Lymphatic Gland is composed of large cells, and others that they are formed of convoluted lymphatic vessels; and some, that the red veins communicate with the lymphatic vessels in the substance of the Gland*. But in order to avoid perplexing

* Non raro mihi in repletionem vasorum lymphaticorum mercurii ope occurrit, liquidum hoc penetrabilissimum absque extravasatione ex vasis lymphaticis in venas sanguiferas transiisse. Hinc cavam venam inferiorem ex injectione

ing a subject of itself too intricate, we shall pass over unnoticed, the various opinions

tione in vasa lymphatica, mercurio plenam inveni nulla interim, ne guttula quidem mercurii per thoracicum ductum, prope insertionem suam ligato in venam cavam superiorem effusa. Glandulam nempe lumbarem semiscirrhosam, per ductum lymphaticum ex pelvi trans arteriam iliacam adscendentem, mercurio replevi. Intravit mercurius in glandulam, ejusque dimidiam partem, inferiorem nempe, pelvi propriam replevit. Resistentia in glandula insignis, columnam mercurii in tubulo injectionis octodecim pollicum sustinebat, nec viam in vas glandulae lymphaticae excretorium, mercurius pandere sibi valebat.

Pressione itaque digiti denique mercurium in ductus glandulae minores, per vas lymphaticum glandulae insertum adegi. Sensi diminutionem fluentis, et fugam ex vasse glandulam intrante, attentus expectabam majorum ex glandula sursum exporrectorum ductuum lymphaticorum intumescuntiam, sed spe mea frustratus, eleganti spectaculo, minutissimos mercurii globulos, in venam ex glandula ad venam inferiorem cavam euntem elapsos, hujus ramulos ad truncum usque expandentes vidi. Per venam hanc, trunco venae cavae in superficie sua exteriori sub exitu spermaticae dextrae insertam, mercurius omnis, per vas lymphaticum ad glandulam advectus, et via quidem magis aperta, sola ponderis mercurii pressione, facili demum negotio in venae cavae truncum transiit ut brevi tempore magna liquidi hujus copia truncum
venae

opinions advanced by different authors who have written on this subject, and endeavour to describe their structure and uses, from the ideas and experiments of the ingenious author of the subsequent discoveries; and as the anatomy of many parts is to be maturely considered, before we can reason on the functions of any one of them (from the mutual depend-

venæ cavæ intraverit, trunculis lymphaticis superioribus, ex glandula exeuntibus, plane vacuis.

Anastomosi in glandulis hisce lymphaticis conglobatis, inter vasa minora glandulæ tortuosa lymphatica ipsa ac venam glandulæ sanguiferam intercedere, nemo vix unquam cogitasset.

Attamen adesse immediatam inter vasa lymphatica et minimos venæ glandularum conglobatarum ramulos anastomosi, nullum amplius post has observationes meas dubium restat. Mercurius enim, in globulos minimos divisus, ductu continuo ex vasis lymphaticis glandulæ in venæ ramulos transiit, nullum præterea in glandula extravasatum aderat, nec liquidum ponderosum, uti mercurius, in resorbentia vascula alia ratione intrare potuisset, nisi per anastomosi five inosculationem, extremitatum vasculorum glandula immediatam atque continuam.

ance

ance they have on each other) we shall first describe their structure, and afterwards inquire into their use.

SECT. I. A LYMPHATIC gland, in size and shape, is commonly compared to a small acorn; though I think it more generally resembles the figure of a kidney bean, being oblong, rounded at the extremities, and a little flattened on the upper and under sides, particularly in the uninjected state. But independent of any change produced by injection, we observe great variety in the size and figure of the lymphatic glands in different bodies, and in different parts of the same body. In some they are large and round, in others small and flat, and in every cluster of these glands, this

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difference

difference in shape and size is observable. Vid. Plate II.

IN females they are generally smaller than in males, and are always considerably less in proportion before the time of puberty than after it.

SECT. 2. THESE glands are dispersed in the course of the lymphatic vessels, in different parts of the body, and through them the lymphatic vessels pass. Their various situations have been already so accurately delineated by Mr. Hewson *, that a repetition would be tedious and unnecessary.

* Hewson on the Lymphatic System, Vol. II. Plates I, II, III, IV.

SECT.

SECT. 3. EACH gland is a congeries of tubes, consisting of arteries, veins, lymphatic vessels and nerves, connected by the cellular substance; the whole forming a circumscribed apparatus for the purpose of secretion. The cellular substance surrounding the gland is a little condensed, and forms what has been called, but improperly, its *capsule*. For though we consider the cellular membrane to be the common connecting medium of all the parts of the body, yet we cannot allow of its forming a peculiar coat to any part; since it cannot be separated from those lymphatic glands, without destroying the texture of them.

SECT. 4. THE branches from the aorta supply the lymphatic glands with blood, in common with all other parts of the body. In general two or three small

branches enter each of these glands at different parts, and these branches ramify to exceeding minuteness throughout the whole gland, and their corresponding veins return the blood into the adjacent venous trunks.

SECT. 5. THE nerves in their course give off extremely small twigs to the lymphatic glands, but not modified to convey an acute sensation; for these glands, unless in a state of inflammation, are very little sensible.

SECT. 6. BESIDES arteries, veins, and nerves, every one of these glands has a number of small lymphatic vessels. They are no where to be found, but in the course of the larger lymphatic vessels, which in their passage from the extreme parts

parts of the body, towards the thoracic duct, enter and pass through the lymphatic glands in the following manner.

SECT. 7. ABOUT a quarter of an inch before a lymphatic enters a gland, it divides into two, three, or four smaller branches, sometimes into a greater number. These enter the gland at the part farthest from the thoracic duct, and are then subdivided into branches, as small as the ramifications of the arteries and veins before described, and which they accompany to every part of the gland. After being thus minutely divided, they reunite and gradually become larger, as they approach the opposite side of the gland, forming three or four branches, which are joined by other lymphatics, that arise from the cells of the gland. All these branches unite together, about

a quarter of an inch from that part where they come out of the gland, and form a common trunk, but larger by the additional lymphatic vessels, it receives from the cells of the gland. See Plate II. Fig. 3.

SECT. 8. SOMETIMES only one lymphatic vessel, and sometimes three or four of them, pass through the same gland, in the manner described above; and these either pass through other glands in the same way, or continue their course on to the thoracic duct. Vide Plate II. Fig. 1. Sometimes we observe, a single lymphatic pass by all the glands, without entering any one of them, and continue on to the thoracic duct. This observation may perhaps account for the venereal, variolous, or other poisons, being sometimes taken into the habit, without inflaming

flaming a lymphatic gland in its passage.

SECT. 9. IN Sect. 3. we said, that each lymphatic gland is a congeries of vessels; and in Sect. 7. we observed, that some lymphatic vessels arose from the cells of the gland: but here we do not mean those appearances which have been called cellular*, (and that are in reality only little eminences, formed by the bending of one vessel round another) but other cells which really do exist in the substance of the gland, and are so very small as to become visible only by the assistance of the microscope.

IF we inject † a lymphatic gland with mercury, or inflate it with air, an irre-

* M. de Haller. Elem. Physiolog. tom. i. page 183.

† Vide Plate V. Fig. 3.

gular appearance is produced, very much resembling cells; and if a gland prepared in this manner, is dried and cut through, at first sight it looks like a honeycomb, but if we examine it more attentively, we shall find this cellular appearance evidently made of convoluted vessels, and by far the greater part of lymphatic glands, that we prepare, the subdivision of the lymphatic vessels into smaller and smaller branches, and not into cells, is apparent to the naked eye. Vide Plate II. Fig. 3, and 4.

SECT. 10. THE cellular appearance in the lymphatic glands is, I think, probably a deception, which may happen in the following way. The very small lymphatic vessels, are very much convoluted, and running in a serpentine direction one over the other, a part of one vessel

vessel is covered by that part of another vessel, which lies over it. This being general, an irregular surface is produced, so that it looks like a number of small globules, or very small pin heads; (vide Plate II. Fig. 1.) similar to what we observe in the *epididymis* when injected with mercury; and that this is really the case, I am convinced, from what I have observed on the examination of other lymphatic glands, when the vessels have been less convoluted, and where the vascular texture has been more evident; for in some we can distinctly trace the continuity of vessels through the glands, especially in the more simple ones.

SECT. II. Plate II. Fig. 2. exhibits a lymphatic vessel A, forming three lymphatic glands: the first at B, is a subdivision of the trunk A, into about nine or
ten

lymphatic vessels, and that the appearance of large cells may be a deception, from the circumstance I have already mentioned; and I am the more confirmed in my opinion that this is the case, on taking a more general survey of this subject in the animal kingdom; as in the turtle, where the lymphatic glands are wanting; or at least that circumscribed form of a lymphatic gland, so general in the more perfect animals, is not to be found in those of the amphibious class.

SECT. 13. IN the mesentery of a turtle, no lymphatic glands are observable; yet in this, animal nature does her business as well, though the apparatus is differently constructed. The small blood vessels in the mesentery of this animal are transparent in an unprepared state, and the large vessels form a network, making
seemingly

seemingly pretty considerable meshes, but if we inject them, (*i. e.* the veins and arteries) we find this part exceedingly vascular, and from its transparency we can here prove the artery terminating in the vein by continuity of canal (a fact not easily demonstrable in the human body); and if we inject the lymphatic vessels, we find them very numerous, forming the most beautiful network imaginable.

The lacteals come from the edge of the intestines upon the mesentery. Part of them ascend, surrounding the blood vessels, but do not communicate with them. These send off lateral branches to the transparent part of the mesentery, whilst others come immediately from the intestines to it, where they divide to exceeding minuteness, making frequent anasto-

anastomoses, and gradually becoming larger as they approach the upper angle, where they communicate with the larger branches, and pass on to the thoracic duct. Vide Plate III.

SECT. 14. THE arteries and veins, are principally spread on the coats of the lymphatic vessels, so that we here find the requisites to form a lymphatic gland; for as we prove, that many of the lymphatic glands in the human body are no more than a congeries of arteries, veins, nerves, and lymphatic vessels convoluted; it is probable, that all lymphatic glands may be formed in the same manner: so, perhaps, it may be the same thing in nature, or the same purposes of animal œconomy may be equally well answered, whether the parts composing a gland (*viz.* arteries, veins, nerves, and lymphatic

phatic vessels) be circumscribed in a proper membrane, or spread over a larger surface. This perhaps will be more fully proved by some experiments and observations, which I shall hereafter publish on the minute structure of glands.

SECT. 15. ON cutting into a fresh lymphatic gland, we find it contains a thickish, white, milky fluid. Then if we carefully wipe, or wash this fluid from any part of it, and examine it attentively in the microscope, we observe an almost infinite number of small cells, not such as have been before described, or that have been supposed to exist in the lymphatic glands, but others too small to become visible to the naked eye, expressed Plate IV. Fig. 4.

SECT.

SECT. 16. If the arteries and veins of a lymphatic gland have been previously injected with a coloured fluid, and a part of the gland be then viewed through the microscope, we observe these cells are extremely vascular; and it is into these cells that the white fluid found in the gland is secreted. This fluid is absorbed by the lymphatic vessels, which we observed Sect. 7. arose from the cells of the gland; and is by them, in common with the other fluids, carried into the course of the circulation.

SECT. 17. THE lymphatic vessels therefore, which originate from the cells of the gland, are in the lymphatic glands analogous to the excretory ducts of other glands; and we have the same proofs that the lymphatic glands secrete this white fluid, and that it is carried from
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the glands by the lymphatic vessels, that we have of glands in other parts of the body separating different fluids, and having excretory ducts; for if we cut into a lymphatic gland we find a white fluid; and if a ligature be made on the lymphatic vessel coming from that gland, we find a fluid of the same kind contained in those lymphatic vessels. This is as convincing a proof of the lymphatic vessels being excretory ducts to the lymphatic glands, and as satisfactory, as that the hepatic duct is the excretory duct of the liver. We know the liver secretes bile, because we find it in that viscus; and we know the *ductus hepaticus* is its excretory duct, because we find bile contained in it. The proofs are similar and equally conclusive.

SECT. 18. * The existence of a white thick mucus-like fluid, in the lymphatic gland, has been long generally known to anatomists, and is particularly remarked by M. de Haller; but the properties of this fluid seem to have been entirely overlooked and neglected.

THIS may perhaps have been owing to the same cause, that the shape of the particles of the blood, till lately, has been so little known, viz. the want of diluting this liquor; for if we examine this fluid in the natural state, we find it a homogeneous mass, discovering nothing of its composition, or properties. But if we

* *Succum glandulis conglobatis inesse, album, serosum lacte tenuiorem, in juniori potissimum, animali conspicuum, id quidem certum est. Eam, cremori similem dixit Thomas Wharton, cinerum Malpighius diaphanum Nuckius album Morgagnius, recte et ad naturam, ut puto omnes. Haller, tom. i. p. 184.*

dilate

dilute it with a solution of Glauber's salts in water, or with the *serum* of the blood, and view it with a *lens* of the $\frac{1}{12}$ of an inch focus, as formerly mentioned in the experiments on the blood, we then observe the following appearance.

SECT. 19. NUMBERLESS small, white, solid particles, resembling in size and shape those central particles found in the vesicles of the blood, are to be seen distinctly gliding down on the stage of the microscope, and if we dilute it sufficiently, we can examine them separately, and view them as distinctly as we can the particles of the blood.

SECT. 20. THESE particles found in the lymphatic glands, likewise agree remarkably in their properties with the central particles found in the vesicles of

the blood, not only as to size and shape, but also in being insoluble in *serum*, or a solution of any of the neutral salts in water (except putrefaction takes place), and are like the blood soluble in water, and in the same order. These particles are by the lymphatic vessels taken into the course of the circulation, and mixed with the blood, where they are for a time retained, to be again separated from it, as we shall see afterwards in our inquiry into the anatomy of some other parts.

CHAP.



C H A P. III.

*On the Situation and Structure of the
Thymus Gland.*

SECT. 21. **T**HE term Gland has been given to certain parts of an animal body, that are by nature destined to separate fluids of different properties from the general mass of blood, which are to be applied to the various purposes of the animal œconomy, or to be excreted, as being either useless or hurtful to the constitution.

SECT. 22. BUT though the term Gland is properly given only to such parts as are known to perform this office; yet it has also been applied to some parts whose uses are unknown; because their structure being apparently the same with that of Glands (properly so called), it has thence been conjectured that their uses might likewise be similar. Thus the Thymus has acquired the name of Gland. In like manner we use the terms Thyroid Glands, and *Glandulae Renales*. For whenever any part receives more blood than is necessary for the immediate growth, or nourishment of that part, it is concluded (*a priori*) that this blood is to undergo some change, or that some secretion is to be made from it. And for these reasons, the appellation of Gland has been given to the Thymus, the Thyroid, and *Glandulae Renales*.

SECT,

SECT. 23. The Thymus is situated in the superior part of the chest, in that space called the anterior *mediastinum*; which in the fetus state, and for a few years after birth, is large. The shape and size of this gland is various; differing in almost every subject. It is triangular, adapted to the space between the right and left lobe of the lungs. The superior part of the gland seldom rises higher than the upper edge of the first bone of the sternum. Sometimes one and sometimes two processes of the same glandular structure, arise from the upper part of the Thymus, and ascend on the fore-part of the neck, almost as high as the *Glandula Thyroidea*; and lies between the *Trachea arteria*, and carotid arteries*; but this is a circumstance that rarely

* Hall. tomus, i. p. 115.

occurs. The two sides of the gland are placed next the lungs, and the inferior part, or basis of the triangle, extends downwards, (sometimes much lower than is expressed in the Plate) lying on the upper and outer part of the pericardium, to which it is attached by the reticular substance. The superior and posterior part of the Thymus lies on that part of the aërta, called *sinus aërtae*, which arises from the left ventricle of the heart to form the curvature, the fore-part of which and the common trunk of the right carotid and subclavian arteries, it generally embraces. The inferior posterior part is always connected with the upper part of the pericardium,

SECT. 24. THE Thymus receives two small arteries, called *arteriæ thymicæ*; which most commonly originate from the

the *sinus aortæ*; sometimes they arise from the curvature of the *aorta*, and I have seen some instances of one small artery coming from the common trunk of the right carotid and subclavian arteries, to the upper part of this gland. Besides these, the Thymus receives several small arterial branches on its fore-part, from the mammary, and other arteries, that supply the mediastinal space with blood.

SECT. 25. THE veins are always more regular in their termination, and are generally two in number. They open into the trunk of the jugular and subclavian veins on the left side; of which a part is covered by the superior portion of the Thymus.

SECT.

SECT. 26. The Thymus is a gland of the conglomerate kind; and like others of that class, has no particular centre of ramification for its blood vessels; but they enter promiscuously at different parts of it. It is formed of a great number of small lobules, or *acini*, united to each other by blood vessels, and the *tela cellulosa*; and over the whole, giving it greater compactness, is a condensed cellular substance, which forms a kind of capsula to the gland, and gives it a pretty regular smooth external surface, except where it is fissured into larger lobes. But this capsula is not of that kind we find on some other glands, as on the kidneys, &c. which can be readily separated from them. It is nothing more than a coarser condensed reticular substance adhering firmly to all parts of it; from which it cannot be separated, without
7 doing

doing injury to the glandular substance.

SECT. 27. MANY attempts have been made, by dissection and other means, to discover an excretory duct from this part. For the organization being apparently the same in it, as in some other known glands, it was but natural to conclude that, similar to them, it also should have an outlet. Accordingly, many fruitless experiments have been made, and much time employed to discover it, but with so little success, that all attempts of that kind seem long since to have been given up. Nay, some have been led into very unphilosophical conjectures (*viz.*) that perhaps it was useless, or that if it did perform any office, it was so obscurely as to escape investigation.

SECT.

SECT. 28. BUT the ingenious author, whose experiments we are about to relate, entertained too exalted an idea of nature, to suppose that any part of the animal frame was useless, though the structure of some parts might be so intricate, and their uses so obscure, as to elude the researches of the most assiduous and ingenious inquirers, into the operations of nature.

SECT. 29. MR. Hewson, after having made many attempts by dissection and injections to discover the use of this gland, with almost as little success as his predecessors, began to employ the microscope; but microscopical experiments, in the manner they were then conducted, afforded no other satisfaction here than that the blood vessels were distributed in a similar manner to those of the lymphatic

phatic glands; but the external appearance, as well as the minute structure of the Thymus, (so exactly corresponding with the structure of other glands) convinced Mr. Hewson, it must have an excretory duct; yet possibly it might be so small, or the coats so transparent, that when collapsed in the dead body, it might become almost invisible; though during life, while distended with the natural fluid, it might be more readily perceived. Therefore the following experiments were made in order to detect it.

EXPERIMENT I.

SECT. 30. THE sternum of a half grown dog being removed, a ligature was passed round the Thymus; including at
the

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the same time all the neighbouring parts. The animal soon died. On examining the parts contained within the ligature, no excretory duct could be found; but a great number of lymphatic vessels made their appearance, filled with a darker coloured fluid than ordinary*.

As the gland in this dog was small, it was suggested that the experiment would probably succeed better in a larger animal, which gave rise to the following experiments.

* Ubinam hic succus habitet nondum consentitur, Ex thymi tamen exemplo, maximæ glandulæ crediderim cum Nuckio in areolis cellularum residere. Nam in tota thymi glandula ubicunque læseris exiguo etiam vulnere in eam violationem exprimi potest, neque tamen aut manifesta cavitās reperitur, qua contineatur, neque ex vase aliquo effluere videtur, cum et copia eam guttulam superet, quæ ex vase non magno inciso speretur, neque ex remotis glandulæ partibus per vascula adeo facile in valvulis urgeri possit, et denique manifesto cum spuma ex cellulis cavernulisque exprimatur. Hall. Elem. Phy. tom. i. p. 184.

EXPE-

EXPERIMENT II.

SECT. 31. THE chest of a calf being opened, a ligature was passed round the lower part of the Thymus, as had been done in the former experiment, and the parts contained within the ligature were taken out. On examining these very attentively, a great number of lymphatic vessels, containing a fluid almost similar to chyle, of a white colour, but not quite so opaque, were seen coming from every part of the gland; one of which was so large, that at first sight it had the appearance of an excretory duct; but on a more attentive examination, it was discovered to be no other than a large lymphatic

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phatic vessel. The remaining parts were dissected with all possible care, but no excretory duct could be seen.

SECT. 32. THE fluid found in the lymphatic vessels, coming from the Thymus, differing so much in colour from what is contained in the lymphatic vessels of the other parts of the body, was an inviting circumstance to examine the properties of it, with intent to determine upon what cause this remarkable difference in colour depended.

EXPERIMENT III.

SECT. 33. A DROP or two of the fluid found in the lymphatic vessels, coming from the Thymus Gland, being received
upon

upon a thin piece of glass, and examined in a microscope, with a lens of $\frac{1}{4}$, of an inch focus, it appeared opaque, and like a drop of milk. But on diluting it with a few drops of the *serum* of human blood, the same appearance was exhibited, as was observed on examining the fluid found in the lymphatic glands, (*vid.*) a great number of small, white solid particles, exactly resembling in size and shape the central particles in the vesicles of the blood; or such as are found in the fluid of the lymphatic glands.

EXPERIMENT IV.

SECT. 34. A few drops of the same kind of fluid as in the former experiment, were diluted with a small quantity of a solution of Glauber's salts in water, (as

G mentioned

mentioned in experiments on the blood) and on viewing this with the microscope, the same particles were more distinctly seen than in the preceding experiment, on account of the fluid being more diluted.

SECT. 35. PARTICLES of this shape being found in large quantities in the lymphatic vessels, coming immediately from the Thymus, through the substance of which lymphatic vessels ramify to every part, gave reason for suspecting that these lymphatic vessels were possibly the excretory ducts of the Thymus: and the following experiment proved the conjecture to be well founded.

EXPE.

EXPERIMENT V.

SECT. 36. ON cutting into the substance of the gland, it was found to contain a white thick fluid*; in most respects resembling the fluid found in lymphatic glands, only in larger quantity. A small portion of this fluid being received on a thin piece of glass, was diluted first with *serum*, then with a solution of Glauber's salt in water, and examined with a microscope. In both these experiments the appearances were exactly the same, as we have related in the

* Interiorem si tumeris fabricam, in omnibus, quos unquam vidi, fetibus reperies, incisione facta, quocumque loco visum fuerit, ut tamen omnino caro glandulae laedatur, succum lacteolum, frequenter etiam sanguine tinctum, ejusque non minimam copiam exprimi posse. Pressa quacunque glandulae parte succus in vulvum confluit. Eum succum stillatitius vini liquor in grumos cogit.

Hall. tom. iii. p. 116.

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Experiments third and fourth; namely, numberless small particles precisely corresponding with those found in the lymphatic vessels, passing from the Thymus; and with those found in the fluid of the lymphatic glands.

EXPERIMENT VI.

SECT. 37. A small portion of the Thymus Gland having remained in water a few minutes, in order to wash the white fluid from its surface, was examined with the microscope, and the cellular appearance was seen here as evidently as in the lymphatic gland, which it in every respect resembles.

SECT. 38. FROM these experiments we are led to make the following conclusions.

clusions. That one use of the Thymus, is to secrete from the blood a fluid, containing numberless small solid particles, similar to those found in the lymphatic glands; and that the lymphatic vessels arising from the Thymus, convey this secreted fluid through the thoracic duct into the blood vessels, and thus become the excretory ducts to this gland. That the structure and uses of this gland are similar to those of the lymphatic glands, to which it may be considered as an appendage. And that this is the fact, is more probable, from observing, that the Thymus exists during the early periods of life only; when those particles seem to be most wanted.

SECT. 39. PROBABLY the Thymus is formed in the human embryo, in the same proportion with all the other parts of the

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animal. It appears distinctly about the end of the third or beginning of the fourth month from conception. From this period to the time of birth, its size is considerably increased, when it is commonly about the size of a small walnut, though not of that figure. In some, it is much bigger; but in others, it does not exceed the size of a large filberd-nut.

SECT. 40. FROM the time of birth to the end of the first year, the gland continues to grow larger, and keeps pace with the general growth of the other parts of the body. From the end of the first to the third year, it is neither perceptibly increased nor diminished, but preserves nearly the same size it had acquired at the end of the first year. From the third to the eighth, or tenth, it decreases

creases in size, and gradually wasting, becomes less and less till the child has reached to between its tenth and twelfth year, when ordinarily it is perfectly effaced; leaving only a ligamentose remains, that degenerates into a kind of reticular substance. As the gland becomes less, the vessels that supplied it with blood for secretion diminish in proportion, and at length when the gland totally disappears, these, like the umbilical vessels, being no longer wanted, degenerate into mere ligaments. Sometimes, though very rarely, they continue pervious (but their diameters are exceedingly contracted), and carry blood to the remains of the Thymus, and the Mediastinum.

SECT. 41. THIS curious circumstance of the Thymus being largest in

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the earlier periods of life, and becoming gradually less, as the animal advances towards maturity, constantly takes place in the human subject: though the periods, when these changes happen, may vary occasionally; and it is probable, that they do so in some degree in almost every individual. But I have never seen an instance of the Thymus continuing till the time of puberty. These changes in the Thymus are not confined to the human body. The same generally take place in all quadrupeds. The Thymus of a calf, called by butchers, the *neck sweet-bread*, is not found in the bullock of eight years old; at that age it is entirely wasted, and the same change obtains in every other quadruped that I have had an opportunity of examining.

SECT,

SECT. 42. THE inference naturally drawn from these experiments is, that the Thymus is necessary to perform an office requisite in the fetus state, and in the early part of life depending upon respiration.

WHAT this office is, we shall hereafter endeavour more fully to explain.

CHAP.



CHAP. IV.

On the Situation and Structure of the Spleen.

SECT. 43. **I**T hath at all times been matter of surprise among the learned, that a viscus so large, and so advantageously situated as the Spleen is, added to the frequent opportunities of inspecting it in different states of health, should, notwithstanding, have its uses so involved in obscurity, as to elude the researches of so many ingenious and industrious inquirers.

SECT.

SECT. 44. NOT that the Spleen has at any time been considered as useless, for at different periods a variety of different offices have been assigned to it.

Among the ancients, the most celebrated opinion was, that it made the *atrabilis* or *succus melancholicus*, which they supposed was carried by the *vasa brevia* into the stomach: but later observations have entirely exploded that idea, in so much that the very term is almost extinct. And we shall endeavour to prove, that the more modern opinion, of its producing some change on the blood, preparatory to the secretion of bile, hath no better foundation in nature.

SECT. 45. BUT it will be unnecessary to repeat the various opinions that have been entertained at different times respecting the use of this viscus. Our

present

present endeavour will be to describe its situation and structure, and afterwards to inquire into some particulars respecting its use.

SECT. 46. THE Spleen then, forms the superior part of the abdominal *viscera* on the left side; its figure is rather oblong, a little convex on its outer or upper, and a little concave on its inner or lower side; it is placed obliquely in the left hypochondrium, with its convex surface exactly corresponding with the concave or under surface of the diaphragm, to which it sometimes adheres, but is always in contact with it, unless when the left lobe of the liver extends very far over into the left side, and covering the upper surface of the Spleen is interposed between it and the diaphragm; which is sometimes, though very rarely, the case. The inner or concave

cave side of the Spleen, from its oblique situation, is turned a little downwards, looking at the same time towards the spine; and to this part a portion of the *omentum* is attached. The edges of the Spleen are not thin like those of the liver, but thick and round, giving a spheroidal figure to the whole.

SECT. 47. BUT the Spleen is not uniformly of the figure above described, sometimes we find it fissured into two or three lobes, almost dividing it into, so many distinct spleens, and frequently we find the edge of it serrated.

SECT. 48. IT is generally a solitary viscus, yet two * distinct Spleens have

* Hall. tom. vi. p. 387. Est tamen unus tantum quamvis præter naturam duplex quoque nonnunquam observatus sit. Adr. Spigelius de humani corporis fabrica. Cap. xiv. p. 309.

been found in the same body, sometimes three, and sometimes a cluster, as it were, of little Spleens; but these are extraordinary deviations from the general conformation of the body, and when found, may properly enough be considered as so many *lusus naturæ*.

SECT. 49. THE ordinary weight of the Spleen is from six to ten ounces; in some subjects it has been found very large, exceeding the weight of five pounds; but as this preternatural enlargement is ever found to be the effect of disease, so from disease in other cases, or from some cause existing in the body, it is found considerably diminished. One instance, I have also seen of a Spleen not more than one ounce in weight, yet it had the appearance of being perfectly sound.

SECT.

SECT. 50. FROM the Spleen being in contact with the diaphragm, and not fixed to the sides of the *abdomen*, its situation will be continually varying in the act of respiration, which will occasion much difficulty to determine at all times the exact situation of it.

SECT. 51. A SPLEEN weighing nine ounces most commonly measures about six inches long, and four inches broad.

SECT. 52. IN a well-formed chest, in a state of the deepest expiration, from the cartilaginous margin of the thorax to the highest lateral part of the diaphragm, generally measures about six inches; therefore, supposing this to be the standard in the utmost expirations, the upper end of the Spleen will ascend so high up as the lower edge of the eighth rib, and

in this state, the inferior part will be opposite to the lower edge of the tenth rib, or the whole of the Spleen will be contained between the eighth and tenth ribs. In the deepest inspirations it never descends below the cartilaginous margin of the chest, unless it be preternaturally enlarged. Thus by attending to the state of respiration, we may be able to form a good judgment of the situation and extent of this viscus; but if we wish to determine it with greater exactness, let the arm be raised as high as possible, and a line drawn from the inferior angle of the *scapula*, parallel to the spinous processes of the *vertebræ dorsi*; the whole of the Spleen will be contained within the line drawn, and be found to occupy the space between the eighth and tenth ribs in a state of expiration; but in a deformed chest, or the chest of a woman whose

whose ribs are pressed in by stays, it may differ considerably. In a woman whose ribs had been pressed in by stays, but not more than is ordinarily found, from the cartilaginous margin of the eleventh rib to the centre of the diaphragm, measured six inches and a half. The Spleen weighed nine ounces two drachms and a half, and measured five inches and three quarters in length, three inches and seven-eighths in breadth, and one inch seven-eighths in thickness; the upper edge was opposite to the upper edge of the eighth rib, and the lower part was opposite to the upper edge of the eleventh rib; thus the whole Spleen in this subject was placed between the eighth and eleventh ribs. And this will in females, I fancy, be found to be the general standard.

SECT. 53. THE Spleen has generally been described of a dark, blueish, leaden, or livid colour, and this is the aspect it commonly wears when we examine it in a body a few days after death, or when putrefaction has taken place; but if we examine it in a human body a few hours after death, or in an animal soon after it has been killed, we find it of a deep red, or blood colour, which gradually changes as putrefaction advances. We shall therefore conclude, that the colour, which has been generally considered as characteristical of the Spleen, is no more than the effect of that change which takes place in all animal substances after life is extinct.

SECT. 54. THE Spleen, in common with all other *viscera* contained in the cavity of the *abdomen*, hath an external covering

covering from the *peritoneum*: Under the peritoneal coat is a proper *capsula* surrounding the whole gland, and to which its tender substance closely adheres.

SECT. 55. THE substance of the Spleen, particularly if putrefaction hath taken place, is extremely soft and tender, readily breaking down under the touch, and exhibiting that appearance called by the Greeks *parenchyma**: and at the first sight, it hath much the appearance of effused blood; but many experiments prove that this tender substance is no other than very small vessels broken down by putrefaction, and not *parenchyma*.

SECT. 56. ON cutting into the Spleen, many small ligaments are seen passing

* Quarta denique, *parenchyma* in qua sanguis effusus citra venas nulla serie dispositus.

Adriani spigelii de humani corporis fabrica, 108.

from side to side of it, and those in quadrupeds being large and intersecting each other, gave rise to the opinion, that the Spleen was full of large cells into which the blood was thought to have been poured: and these cells were supposed to be demonstrated by a Spleen prepared in the following manner. An injecting pipe being fixed into the artery or vein of the Spleen of an ox, warm water is injected, and the substance of the Spleen is kneaded (by which the small vessels are broken down) with the hand; the bloody water being pressed out, and with it the small vessels, fresh water is injected, and this process repeated until the water returns colourless; it is then inflated and dried. On cutting into a dried Spleen thus prepared, it exhibits a cellular appearance, which has been called the cells of the Spleen, but although these cells are artificial,

artificial, and the structure of the gland is entirely destroyed by that mode of preparation; yet we shall presently endeavour to prove, that there are cells, but of a different sort, existing in the substance of the Spleen.

SECT. 57. THE Spleen is composed of arteries, veins, nerves, and lymphatic vessels, which are distributed to every point of it, so that it seems a mere congeries of vessels, and consequently receives a very large quantity of blood; and for that cause it has been very properly supposed to be a gland; and agreeable to that idea, anatomists have made every attempt that their invention could devise, to discover its excretory duct, but without success.

SECT. 58. THE *aërta*, whilst in the cavity of the *abdomen*, gives off from its fore-part three branches: the first of these, called the *cœliac artery*, springs from the main trunk of the *aërta* as soon as it enters the cavity between the two *crura* of the diaphragm; and is immediately divided into three distinct branches; the first of which is called the *conorary artery of the stomach*, and carries blood to the lesser curvature of the stomach. The second branch, which carries blood to the liver for its nourishment, is called *arteria hepatica*. And the third branch, which is that we are now about to trace, is called *arteria splenica*, and carries blood to the Spleen.

SECT. 59. THE splenic artery, in its passage to the Spleen, runs in a *fulcus* through the whole length of the *pancreas*,
and

and by several small branches supplies that gland with blood for the secretion of the *succus pancreaticus*; besides which, in its course nearer toward the Spleen, this vessel also gives off four other arterial branches, called *vasa brevia*, which are distributed to the greater curvature of the stomach, and the last of these going near the left extremity of the greater curvature, is called *gastrica sinistra*. The trunk of the artery then passes on to the Spleen, and is divided into five or six branches, which enter the concave side at the *sulcus* or sinuosity, of the Spleen, and as soon as they have passed through the *capsula*, are divided into exceedingly small twigs, which are distributed to every point of the gland. The arteries, thus minutely divided, transmit the redundant blood to the veins, which becoming larger as they approach nearer to the sinuosity of the

Spleen, at length pass out in branches, which every where accompany the arteries that entered it; these branches uniting form the splenic vein, *the blood of which will not coagulate by exposition to the air, like other venous blood.* The trunk of the vein then attends that of the artery, receiving veins from the stomach and pancreas, which correspond with the branches given off by the artery; the vein then passing on joins other veins from the intestines, &c. which transmit their blood by the *vena portarum*, to the liver, for the purpose of secretion.

SECT. 60. LYMPHATIC vessels in great numbers may be distinctly seen running every where on the external surface of this gland; in so much that the Spleen of a calf has ordinarily been chosen on which to demonstrate the lymphatic vessels;

vessels; and they are also as numerous in the internal substance as on the external surface, which we can prove in fish, whose lymphatic vessels are without valves, so that we can inject them from trunk to branch. Now if we fill the lymphatic vessels coming from the Spleen of a fish with a red injection, we can colour the gland as highly as if it had been injected by the artery or vein; hence it is evident, that the lymphatics are co-extended with the blood vessels to all parts of this gland,

SECT. 61. IN the human body, the lymphatic vessels pass through some lymphatic glands which are situated near the sinuosity of the Spleen, from whence they pass on towards the thoracic duct, into which they empty themselves.

SECT.

SECT. 62. THE nerves inservient to the Spleen are branches from the *par-vagus*, and intercostal nerves, which form a *plexus* called the splenic; these enter the sinuosity with the blood vessels, and attend them through their minutest ramifications.

SECT. 63. THUS we have shewn that the Spleen is extremely vascular; in so much that when injected it appears a mere congeries of vessels, and that the quantity of blood circulating through it is very considerable,

SECT. 64. IN Section 56, we said, that there are cells in the Spleen, but not of the kind commonly supposed to have been demonstrated in Spleens prepared as there described; but although we deny the existence of such large cells (which
are

are no other than what may be called the skeleton of a Spleen, made by destroying its minute structure) yet we assert, that there are innumerable cells dispersed throughout the whole substance of the Spleen, but they are so very small as to be discovered only by the aid of a microscope: these may be seen in the following manner.

SECT. 65. TAKE a small thin piece of a Spleen that has been minutely injected (*i. e.* the arteries and veins completely filled with a coloured injection), steep it a day in clean water, changing the water frequently, upon examination of this with a lens $\frac{1}{3}$ of an inch focus, an almost infinite number of cells may be distinctly seen: the round figure of which, as well as their great regularity, sufficiently distinguishes them from the irregular

irregular interstices of the reticular substance. The size and shape of these cells so nearly resemble those we have before described in the lymphatic glands, that a tolerably accurate idea of them may be obtained by referring to Plate IV. Fig. 3. The ultimate branches of the arteries and veins are so distributed, as to form a most beautiful net-work of blood vessels upon each particular cell, and we shall render it probable, that the extreme branches of the arteries form a secretion into these cells.

SECT. 66. MR. HEWSON, in the beginning of his inquiries after the excretory duct of the Spleen, was not more successful than his predecessors had been; but having observed that the lymphatic vessels were the excretory ducts of the lymphatic glands, and also, that the lymphatic

phatic vessels of the Thymus performed the office of an excretory duct to that gland, he was led, from this circumstance, to conjecture that the great number of lymphatic vessels found in the Spleen, might possibly be intended to return the secreted fluid from it, and thereby become in effect its excretory duct. In order to discover if his conjectures were well founded, the following experiments were made.

EXPERIMENT I.

SECT. 67. A DOG was opened alive, and after a ligature had been passed round the splenic vessels, the whole Spleen was cut out.

SECT.

SECT. 68. ON examination of the lymphatic vessels upon the surface of the Spleen, they were found very turgid, and the fluid contained in them appeared of a much darker colour than he had observed in any other lymphatic vessels; on puncturing one of the largest of these vessels, a small quantity of the fluid it contained was received into a tea-cup, which was red, and coagulated soon after being exposed to the air.

SECT. 69. MR. HEWSON soon discovered, that a dog was an unfavourable subject on which to make this experiment completely, because, in that animal, the splenic blood vessels, both arteries and veins, are divided into many branches, which enter the Spleen at some considerable distance from each other. Therefore the following experiment was made,

EXPE-

EXPERIMENT II.

SECT. 70. As soon as a bullock was killed, and the *abdomen* opened, a ligature was passed round the splenic vessels, (which in this animal enter the Spleen at its upper part) and tied; the lymphatic vessels which accompany the artery and vein, were also included in the ligature; and as absorption continues so long as the animal remains irritable, the lymphatic vessels, over the whole surface of the Spleen, soon became turgid, and were distinctly seen filled with a red fluid, so highly coloured as equal parts of claret and water: the larger lymphatic vessel was then opened, and a quantity of the fluid it contained was received into a tea-cup; which, on being exposed to the air, soon coagulated.

EXPERIMENT III.

SECT. 71. A PORTION of this fluid was diluted with pure *serum*, when the red colour seemed evidently owing to a quantity of red particles, which were distinctly seen in very considerable numbers.

SECT. 72. But lest it should be objected, that the red particles were contained in the *serum*, this experiment was carefully repeated.

EXPERIMENT IV.

SECT. 73. ANOTHER portion of the fluid received from the lymphatic vessel, was diluted with a weak solution of the

Glauber's salts, when exactly the same appearances were exhibited as were formerly mentioned in experiments upon the blood: so that there can be no doubt, but that the red colour of the lymph from the Spleen, is communicated to it by a quantity of red particles of the blood.

SECT. 74. IT may be objected to Experiment II. that the animal, in being driven to the slaughter-house, might have received some blow on the Spleen, by which blood was extravasated, or that extravasation might happen in the very act of killing, and that this newly extravasated blood might be absorbed and found in the lymphatic vessels in the form of red particles.

SECT. 75. To these objections we answer; first, that the Spleen is so well defended from external injuries, that it is very improbable such accident could happen. And secondly, that if such an accident had really taken place, the lymph at the greatest distance from the ligature should be of a redder colour; which is not the fact; for the colour of the lymph in any of the lymphatic vessels of the Spleen, as nearly as we can determine, is the same; but that which is nearest the ligature, to a careless observer, seems to be of a deeper red; but this appearance is occasioned only by the quantity being larger from the increased size of the vessel.

SECT. 76. THESE experiments were frequently repeated during Mr. Hewson's life-time, and many times since his decease,

cease, and the appearances have been uniformly the same.

SECT. 77. THAT the Spleen is the organ ordained by nature for the more perfectly forming these red particles, we shall endeavour to prove in the next chapter.



CHAP. V.

Containing an Account of the Manner in which the Red Particles of the Blood are formed, deduced from the Experiments and Observations related in the preceding Chapters.

SECT. 78. **I**T hath been shewn, in a paper delivered by the late Mr. Hewson*, and read June 17th and 24th, 1773, intituled, "An account of the figure and composition of the red particles of the blood, commonly called the Red Globules;" that these red

* Vid. Chap. I.

particles

particles are not globules, as was generally believed, but that each particle is a compound body consisting of two parts, *viz.* an external portion, which, from its resemblance to a small bladder, is called a vesicle; and an internal, contained in the centre of this vesicle, which is called the central particles; and that these particles while circulating in the blood-vessels in their natural state, are not spheres, but round and flat, resembling a piece of money.

SECT. 79. THIS fact has been proved by experiments; first, if the red particles of the blood be diluted with fresh *serum*, and examined with a microscope, their flat figure may be immediately discerned, and the shape of the particles remain unaltered; but if a small quantity of water be mixed with these particles, they are

immediately transformed from a plane to a sphere, the vesicle will gradually dissolve, and dissolving becomes transparent, at which time the central particle may be seen rolling from side to side like a pea in a bladder; the vesicle at length bursts, and the central particle will be entirely disengaged from it; but if a drop or two of a solution of any neutral salt be added to this mixture before the bursting of the vesicle, it immediately becomes flattened, and the particle of blood reassumes its original figure. In the natural state of a particle of blood, the vesicle is collapsed, and is in contact with, or adheres to, the central particle so firmly as to retain the particle in the middle of it; but when water is added to the blood, and the vesicle becomes a sphere, that union is broken, the central particle becomes loose in

in the vesicle, and then only its motion can be distinguished.

SECT. 80. THE figure and size of the particles of the blood differ in different animals; but the general conformation of vesicle and particle extends probably throughout animal nature. That particles thus formed, should not be made by the mere agitation of the chyle in the lungs, seems probable; that they are not, it shall be our business to prove; and also, that the lymphatic system and its appendages are the organs employed by nature to do this office. By the lymphatic system and its appendages, we mean, the lymphatic vessels, the lymphatic glands, the Thymus, and the Spleen.

SECT. 81. AT the first view it may seem extraordinary, that nature should

have given so many and so complicated organs, to form a part only of the blood, when she effects other secretions by organs apparently more simple; but our surprise must cease when we reflect, that upon a due formation of these particles, not only the various functions of the body, but also the very existence of the animal, in a great measure depends. When we consider how liable these parts are to disease, by which their offices would be impeded, we must necessarily admire the goodness of the author of our nature for so forming these parts of our body, that the disease of a part should not be attended with the destruction of the whole.

SECT. 82. THE lymphatic vessels, which arise from every part of the body, have already been described as performing the office of absorption, or taking all those fluids

fluids into the body, by which alone the animal is supplied with nourishment for its preservation and growth; and the lymphatics not only do this, but they also assist in forming the red part of the blood.

SECT. 83. EACH lymphatic vessel is vascular, and, when minutely injected, appears to have more blood vessels than are necessary for the nourishment and growth of that vessel. The coat of each lymphatic is likewise muscular, and consequently has a power of diminishing its capacity upon the application of a stimulus.

SECT. 84. THE lymphatic glands through which the lymphatics pass, secrete a fluid which, when examined with a microscope, Chap. I. Sect. 19. exhibits

exhibits numberless small solid particles, exactly resembling in size and shape the central particles contained in the vesicles of the blood. The lymphatic vessels which arise from the cells of the lymphatic glands, into which the central particles are secreted, we have called Chap. II. Sect. 17. the excretory ducts of the lymphatic glands, which convey the secreted particles into the lymphatic vessels which pass through the gland, and from thence they pass on through the thoracic duct, into the blood vessels.

SECT. 85. IF we open a lymphatic vessel after it has emerged from a lymphatic gland, we find not only a great number of these central particles, but also many of the particles of the blood completely formed ; that is, the central particle is surrounded by a vesicle. We may conjecture

conjecture with a great degree of probability, that the vesicle is either a secretion from the internal coat of the lymphatic vessel, or that the lymphatic vessel has a plastic power over its contained fluid, so as not only to form a vesicle round the central particle, but also to give it its red colour, for till the red vesicle is formed, the central particle is evidently white.

SECT. 86. THAT a lymphatic vessel, after it has passed through a lymphatic gland, contains lymph, red blood, and central particles, will not admit of a doubt to any one who will take the trouble of making the experiment. How then are these red particles formed, if not by the lymphatic vessels?

SECT.

SECT. 87. CHAP. I. SECT. 19. we prove, that central particles are formed in the lymphatic glands; and from our finding them in the lymphatic vessels, presently afterwards taking on their vesicular portions, or being completely made, we cannot doubt but that the lymphatic vessel gives them the red vesicle; but in what manner this is performed, whether by a secretion from the internal coat of the vessel, or by a plastic power of the vessel itself over its contained fluid, is perhaps a circumstance among the *arcana* of nature too minute for human investigation.

SECT. 88. AND it is amply sufficient to our purpose to prove, that the lymphatic vessels and glands are of themselves capable of forming the red part of the blood.

SECT.

SECT. 89. IT will probably be asked, if the lymphatic glands are given to form the central particles, how are those particles formed where the lymphatic glands are wanting, and yet the red blood is perfect? In answer to this, we beg leave to repeat what has been observed in a former Chapter, that though animals of the amphibious class have not that circumscribed form of lymphatic gland which we find in the human body, and in the bodies of quadrupeds, yet nature has in them constituted a different apparatus to serve the same end; namely, a net-work of lymphatic vessels on the meshes of the mesentery found in the turtle. For, as we have already shewn, the supposed cellular structure of the lymphatic glands is by no means necessary to constitute a lymphatic gland; it is very probable, the ultimate branches of the

*

lymphatic

lymphatic vessels in the mesentery of the *amphibia*, may perform the same office in that class of animals, which the small cells do in the human body, or in the bodies of quadrupeds; that is, as the central particles in those animals which have lymphatic glands are formed in the small cells of those glands, so nature in the amphibious class makes the ultimate ramifications of the lymphatic vessels do that office; so that the same purposes of animal œconomy may be equally well effected, whether the parts composing a gland are circumscribed in a proper membrane, or whether the same parts are spread out over a large surface.

SECT. 90. IT may be objected by some, that the appearance of central particles may be a deception, for that appearance may be seen in many fluids; but
the

the Red Particles are formed. 27

the uniformity of their figure in the same sort of animal, and the difference of their size and shape in different animals, will put this matter out of dispute. In birds, as the common fowl for instance, the particles of the blood are oblong like a plumb-stone (*vid.* Plate), and the central particles found in the lymphatic glands of that bird are also oblong, corresponding in every respect with the central particle found in the vesicle of the blood of that animal.

SECT. 91. IN Chap. III. it was observed, that the structure of the Thymus gland is similar to that of the lymphatic glands, and that it secretes from the blood particles like those secreted by the lymphatic glands; in fine, in its office, that it is no more than a large lymphatic gland. But why should the Thymus be
large

large in the *fœtus*, and as the animal increases in size, become smaller and smaller until at length it quite disappears; or, in other words, Why does not the Thymus, like the liver or *pancreas* continue through life? The reason why the Thymus is larger during the early part of life, is, we conceive, that it may act as an auxiliary to the lymphatic system, for the purpose of forming more of the central particles of the blood, than could have been made by the lymphatic glands alone during that time, when nature wants them most; for the human body grows more, in proportion to its weight, from the second month after conception to the end of the third year, than it does in any future period of its existence of no longer duration; a greater quantity of blood is therefore wanted and applied by the constitution in the quick growth of the

the animal, than is ever afterwards applied to that purpose in the same time.

SECT. 92. IF the Thymus Gland were wanting in the young animal, the lymphatic vessels and glands must have been made considerably larger than they now are, or out of proportion to the other parts of the body; otherwise the animal could not have been duly nourished, and the purposes of nature must have been defeated; but by the assistance of the Thymus, a sufficient quantity of the central particles, to be converted into blood, necessary for the growth of the animal, are formed; and nature at the same time preserves a just proportion in the lymphatic system; then, as the animal becomes larger, and of consequence the lymphatic system more extended,

K

that

that alone and unassisted can now furnish a sufficient quantity of these particles for the growth of the animal and repair of the constitution; the Thymus being no longer necessary, and occupying a space which by this time will become useful for other purposes, the size of it will be gradually diminished, and its parts absorbed into the habit.

SECT. 93. THE Thymus Gland is placed in the chest, because the space it fills is not wanted by the *fetus*. After birth, when respiration takes place and the animal increases in size, the growth of the lungs requires the cavity of the chest to be enlarged, which is done partly by the absorption of the Thymus, but chiefly by the extension of the ribs.

SECT.

SECT. 94. THE Thymus Gland then we consider as being an appendage to the lymphatic glands, for the more perfectly and expeditiously forming the central particles of the blood in the *fœtus*, and in the early part of life.

SECT. 95. IN Chap. II. we considered the lymphatic vessels arising from the cells of the Spleen as its excretory ducts, which term, perhaps, when applied to lymphatic vessels, may be objected to by some, but we think not with reason; for if we consider the office of an excretory duct, we shall find that there is no more impropriety in calling these lymphatics excretory ducts, than there is in using the term excretory duct, to express that tube which conveys the secreted fluid of any other gland to its place of destination.

The excretory duct of the liver conveys the bile into the *duodenum*, because that fluid is required in the intestines for the purpose of digestion. So the lymphatic vessels of the Spleen convey the red particles of the blood into the thoracic duct, and from thence they pass into the blood vessels, which is the place assigned to them by nature, and from whence they are to be conveyed to the different parts of the body, to answer the purposes of nutrition and vivification.

SECT. 96. THAT the Spleen really does secrete the vesicular portion of the red particles of the blood, we have very convincing proofs.

SECT. 97. FIRST, If the Spleen be diseased, the body for a time gradually wastes.

SECT.

SECT. 98. SECONDLY, We have proved, that vast numbers of central particles made by the Thymus and lymphatic glands, are poured into the blood vessels through the thoracic duct; and if we examine the blood attentively, we see them floating in it. Nature surely would not make so infinitely many particles to answer no purpose? What then becomes of these particles after they are mixed with the circulating blood; are they immediately destroyed? No. They are, we believe, carried with the blood to the Spleen, not that the Spleen has any elective attraction over them; but that being equally and uniformly diffused through the general mass of blood, a due proportion of them is received by the Spleen with its arterial blood, and that when arrived there, the Spleen has a power of separating them from the other

parts of the blood, and of depositing them in the cells of that gland already described; where the arteries which are spread out in form of net-work upon the sides of the cells, secrete from the blood the vesicular portion, and that when thus perfectly made, the lymphatic vessels which originate from the cells absorb them, and convey them thence into the thoracic duct, and so into the blood vessels.

SECT. 99. THAT the Spleen does secrete somewhat, is evident, from the change observable in blood drawn from the splenic vein, which is distinguished by this remarkable property, that it will not coagulate like blood taken from other veins; the reason we apprehend is, because the coagulable lymph is employed by nature in the formation of the red
vesicle;

the Red Particles are formed. 135

vesicle ; it remains therefore fluid until the thinner parts have evaporated, leaving the red particles a dry mass.

SECT. 100. FOURTHLY, We have frequently examined blood taken from the splenic vein, but could never distinguish any central particles in it.

SECT. 101. FIFTHLY, In every animal which has red blood, a Spleen is found ; but in those animals which have not red blood, the Spleen is wanting.

SECT. 102. LASTLY, We find that vast quantities of the red particles of the blood are brought from the Spleen, by the lymphatic vessels which originate in its substance ; and for this reason we

have called these lymphatic vessels the excretory ducts of the Spleen.

SECT. 103. THAT the red particles of the blood are completely formed by the Spleen, we have therefore as strong proofs, as we have that the liver secretes bile, or the testicles *semen*; we find bile in the *ductus hepaticus*, *semen* in the *epididymis*, and red particles of blood in the lymphatic vessels of the Spleen.

SECT. 104. IT may then reasonably be asked, How is the red blood formed when the Spleen is taken out, if the Spleen is the *viscus* intended by nature to form the red blood? This objection will militate equally strong against any other use the Spleen is supposed to have; for that the Spleen may be taken out,
and

and the animal suffer but little inconveniency, by no means prove it to be useless, but it proves that some other part is capable of performing its office. Every philosopher must entertain too exalted an idea of nature, to believe that any part of the creation is useless, much less could he suppose a *viscus* in the human body, so large as this is, has no office of importance assigned to it.

SECT. 105. SUPPOSE then for a moment, we allow the Spleen to do the office assigned to it by the moderns, *viz.* that it produces some change on the blood preparatory to the secretion of bile; what must do that office when the Spleen is wanting? for as the animal lives and is well nourished afterwards, if that supposed change is absolutely necessary for the secretion of bile, either some other
viscus

viscus must do its office; or the bile, a fluid so requisite for assimilating our food, could not be formed, and the animal for want of being duly nourished must die.

SECT. 106. If we may reason from analogy, we should say, that it is contrary to the established laws of animal oeconomy, to suppose the use of one organ or gland, to be merely subservient to another organ or gland, in preparing the blood, in order to render it fit for such organ or gland to do its office; it would be asserting, that the liver which nature intended to secrete bile could only do it by the intervention of the Spleen; and yet if we allow that bile can be formed without the use of the Spleen, we admit that intervention to be by no means necessary. But to carry our analogy still farther, nature has given to the animal body certain glands, and has assigned to each

each peculiar offices, that is, she has endowed them with a property of separating from the blood divers fluids, as different from each other, as they are from the mass of blood from out of which they were originally separated.

SECT. 107. THE lachrymal gland secretes the tears; the salivary glands, the *saliva*; the kidneys, urine; the testicles, *semen*, &c. &c. without the intervention of any auxiliary gland. If then a fluid so elaborated, and so different from any thing we find in the blood, as *semen* is, a fluid which has an office of no less dignity than to perpetuate the whole race of animals, can be formed from the blood by the vessels of the *testis*, without any preparatory change being produced on it; may we not reasonably conclude, that the liver is capable of secreting bile from the blood without any

any antecedent change being made on it by the Spleen? For to say that the blood must be prepared by the Spleen, before bile can be secreted from it by the liver, is to deny, that the liver, which is given to form bile, can do the office which nature has intended it to perform.

SECT. 108. BUT if we allow the Spleen to make the red part of the blood, we can readily account for the reason why the Spleen may be cut out of an animal, and yet the animal survive, and suffer but little inconvenience, for though the office of the Spleen is to form the red particles of the blood, yet it is not the only organ in the body capable of doing that office; for we have already proved Sect. 88. that the lymphatic vessels do also form the vesicular portion; the Spleen therefore is not the only organ capable of doing it. But nature has given the

the Spleen as an auxiliary to the lymphatic system, in order to the more commodiously, expeditiously, and completely forming the red part of the blood.

SECT. 109. IF then the Spleen be cut out, or its office obstructed by disease, nature has a resource, in exciting the lymphatic vessels to form a larger quantity of red particles than they had ordinarily been accustomed to do, and these in proportion to the exigencies of the habit; but here nature does not assign a new office to the lymphatic vessels, but only excites them to exert in a higher degree, a power of which they were before possessed; and this notion is conformable to what we observe in other circumstances of animal œconomy; as when an animal is fat and well nourished, the stomach is much longer in performing its office, than it is when emaciated by long fasting,
and

and its life is in danger from want of nourishment, or than it is when the body is wasting by disease, witness the surprising quantities of food the stomach will digest; in a short time after a recovery from the small-pox, or a violent inflammatory fever; under these circumstances, it is astonishing to observe how much Nature will exert herself, and how soon food taken into the stomach will be digested, and applied to the purposes of the constitution: in like manner, most probably, if the Spleen be diseased or cut out, Nature is capable of making the lymphatic vessels exert themselves more powerfully in the execution of their office; or on the contrary, if the lymphatic system be diseased, the Spleen is excited to form a larger quantity of blood in order to make up the deficiency: thereby the life of the animal will be less frequently endangered from a partial disease.

the Red Particles are formed. 143

SECT. 110. But how much soever the manner in which the red vesicle is formed may be disputed, we think it cannot be denied, but that the office of the thymus and lymphatic glands is clearly proved to form the central particles found in the vesicles of the blood; and though the operation of Nature in forming the vesicular portion is more obscure, yet the probability of its being performed in the manner we have related will, we hope, be readily admitted.

SECT. 111. A system so new and so different as this is from the opinions at present so generally entertained of the blood, perhaps may meet with much opposition; and as no doctrine should be admitted in philosophy, till it has stood the test of the most careful and accurate examination, it may therefore be some time before this is universally allowed:

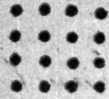
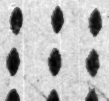
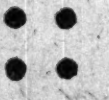
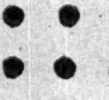
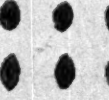
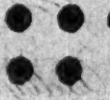
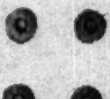
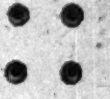
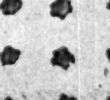
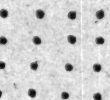
for

for as the experiments are numerous, and some of them not easily made, few, but lovers of science, will take the necessary pains to inquire into them: but we will be bold to assert, that whoever repeats these experiments will be amply rewarded for his trouble. We shall add, that when these facts are viewed with candour, and experiments of this kind are prosecuted with industry, they may probably direct the way to discover many operations of animal œconomy, that are at present considered among the inexplicable *arcana* of nature.

SECT. 112. Having now finished the relation of the facts, and the experiments to prove them, whether the conclusions drawn from them are just, we shall submit to the judgment of the learned reader.

F I N I S.

A comparative view of the **FLAT VESICLES** of the Blood in different Animals, exhibiting their size & Shape as they appear thro' a Lens $\frac{1}{23}$ of an Inch Focus.

- Fig. I.  Their Size in an Ox, a Cat, an Ass, a Mouse, & a Bat.
- II.  in Man, in a Rabbit, a Dog, & a Porpus.
- III.  in Birds, viz a Pigeon, a Hen, a Chafinch, & a Duck.
- IV.  in a Chick from the Egg, on the 6th day of Incubation.
- V.  in the common Fish, as the Salmon, Carp, & eel.
- VI.  in a Full grown Viper, & in a Turtle.
- VII.  Their Size in a small Viper taken from the Belly of its Mother.
- VIII.  in a Slow Worm.
- IX.  in a Frog.
- X.  in a Skate.
- XI.  in a Lobster.
- XII.  The Vesicles of the same Lobster, as they appear after being a short time exposed to the Air.
- XIII.  The size of the Globules of Milk.

DESCRIPTION of the PLATES.

PLATE I.

A Comparative view of the flat vesicles of the blood in different animals, exhibiting their size and shape, as they appear through a lens $\frac{1}{17}$ of an inch focus.

PLATE II.

Fig. 1. Exhibits the Lymphatic vessels of the lower extremity, injected with mercury, passing through a cluster of Lymphatic Glands taken from the groin. The arteries and veins were not injected in this preparation.

a, a, a, a, a, a, a, a, a, a, a, a, a, a, a, a,
a, the Lymphatic vessels.

b, b, b, b, b, b, b, b, b, the Lymphatic Glands
seen of different sizes and shapes, with the
Lymphatic vessels passing through them.

L

A, B,

Description of the Plates.

A, B, C, D, E, Lymphatic Glands that have a cellular appearance.

F, G, Lymphatic Glands evidently formed of convoluted Lymphatic vessels; these likewise shew the manner in which the vessels enter, and pass through the Glands.

H, H, Lymphatic vessels running to the edges of two Lymphatic Glands not injected.

I, I, Lymphatic Glands uninjected.

Fig. 2. Exhibits a Lymphatic vessel that forms three small Lymphatic Glands.

A, A Lymphatic vessel.

B, A Gland made by a subdivision of the trunk *A*, into nine or ten branches, which are convoluted; these reuniting, form the Lymphatic vessel *C*.

C, A Lymphatic vessel ascending to form the Gland *D*.

D, A Lymphatic Gland.

E, A Lymphatic vessel formed by the union of the Lymphatic vessels that composed the Gland *D*, which divides into the two branches *F* and *G*.

F,

Description of the Plates.

F, The Lymphatic vessel subdivided into small branches to form the third Lymphatic Gland *H*.

H, The third Lymphatic Gland.

I, A Lymphatic vessel formed from the Gland *H*, which passed on to communicate with other Lymphatic vessels, not expressed in this Plate.

G, A Lymphatic vessel.

Fig. 3. Exhibits the manner in which a single Lymphatic vessel enters, and passes through a Lymphatic Gland.

a, The trunk of a vessel filled with mercury.

b, The division of the trunk into four branches before it enters the Gland.

c, The Gland, with the Lymphatic vessels passing through it.

d, The Lymphatic vessels having passed through the Gland, form four vessels on the opposite side, to which they had entered the Gland. These vessels unite to form the trunk *e*.

L 2

e, The

Description of the Plates.

- c*, The Lymphatic vessel, having passed through the Gland, is become larger than before it entered the Gland.

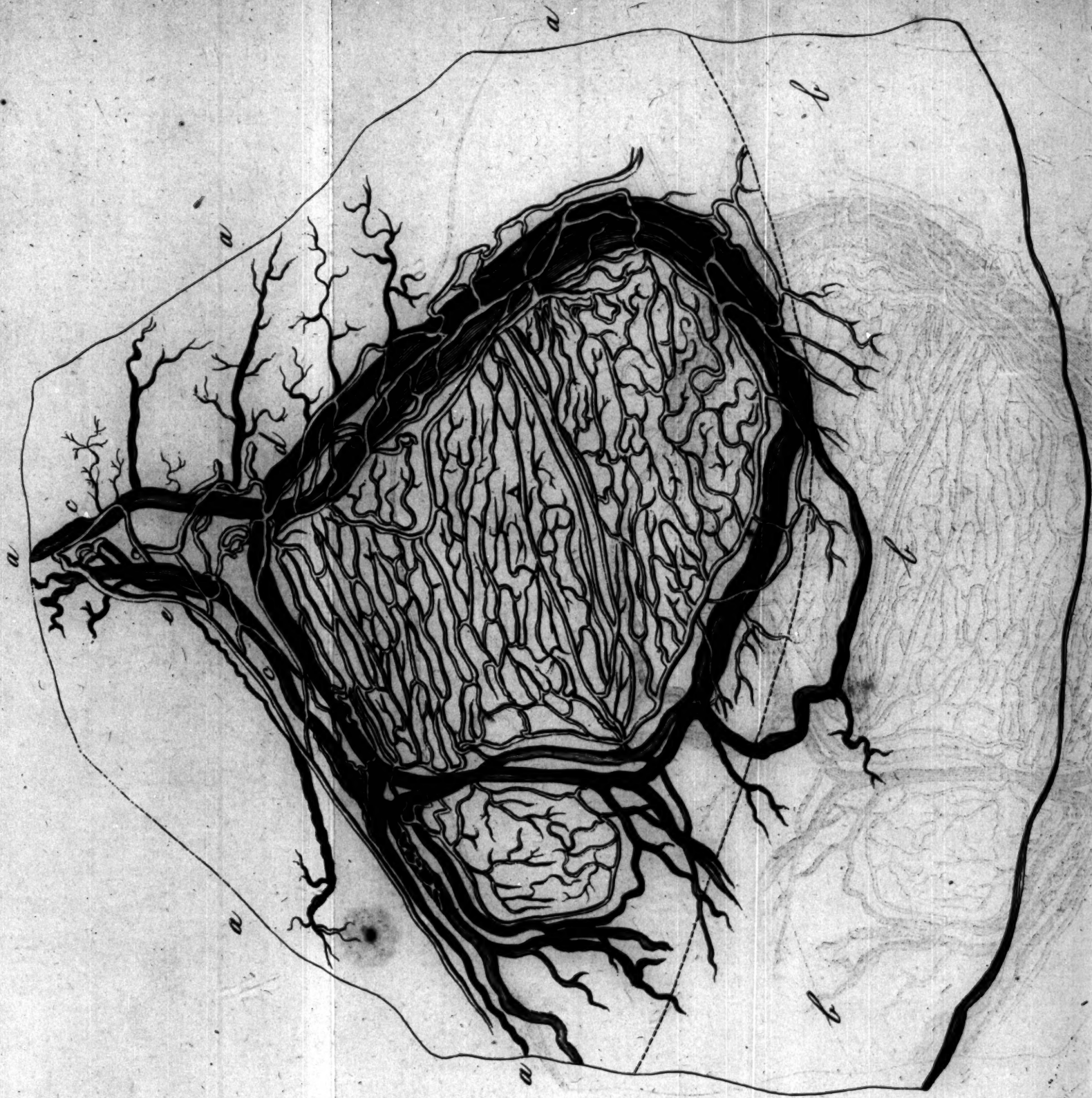
Fig. 4. Exhibits a Lymphatic Gland with the Lymphatic vessels injected with mercury, in which the subdivision of the larger vessels into smaller branches, running in a serpentine direction through the Gland, is apparent to the naked eye.

Fig. 5. Exhibits Lymphatic vessels and Glands, taken from the axilla in which the subdivision of the trunks into branches, and their frequent communication with each other, may be traced distinctly.

- a, a, a*, The trunks of five Lymphatic vessels that come from the arm into the axilla, and as they ascend, divide into many branches, which make frequent anastomoses, and then form the plexus *A*.

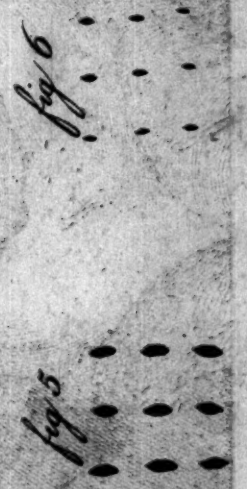
A, A plexus of Lymphatic vessels dividing into two parts *b*, *c*.

- b*, A cluster of Lymphatic vessels that run parallel to each other.



Jas. S. Turner delin. +

W. P. Darling sculp. +



J. S. Turner delin.

W. D. Manning Sculp.

Description of the Plates.

- d*, Lymphatic vessels that surrounded the artery, and passed on to Lymphatic Glands not represented.
- e, f, g*, Lymphatic vessels that form the Gland *b*.
- i*, The Lymphatic vessel arising from the Gland *b*.
- e*, A plexus of Lymphatic vessels communicating frequently with each other, and then ascending divides into the branches *b, l, l*.
- k, l, l*, Lymphatic vessels that passed on to to open into the angle between the jugular and subclavian vein, on the right side, without entering any Lymphatic Gland in their passage.

P L A T E III.

Exhibits a part of the mesentery of a turtle injected. The arteries were filled with red wax, the veins with black, and the lacteals with mercury.

The mesenteric artery, and vein, as they pass on to the gut between two folds of the peritoneum, divide into branches that make frequent

Description of the Plates.

frequent anastomoses. These larger vessels leave spaces that resemble a net-work, and form meshes of different sizes. These in the unprepared state are transparent; but when the blood vessels are minutely injected, we observe several small arteries, and veins, ramifying to the utmost minuteness. And from the transparency of the peritoneum, we can here distinctly trace the artery terminating in the vein, by continuity of canal. It is on these meshes that the lacteals, as they come from the gut upon the mesentery, divide into innumerable branches, that communicate frequently with each other, and form a beautiful plexus of lacteal vessels. That in its office, we consider analogous, to the Lymphatic Glands, seen in the mesentery of other animals.

a, a, a, a, a, The outline of the mesentery,

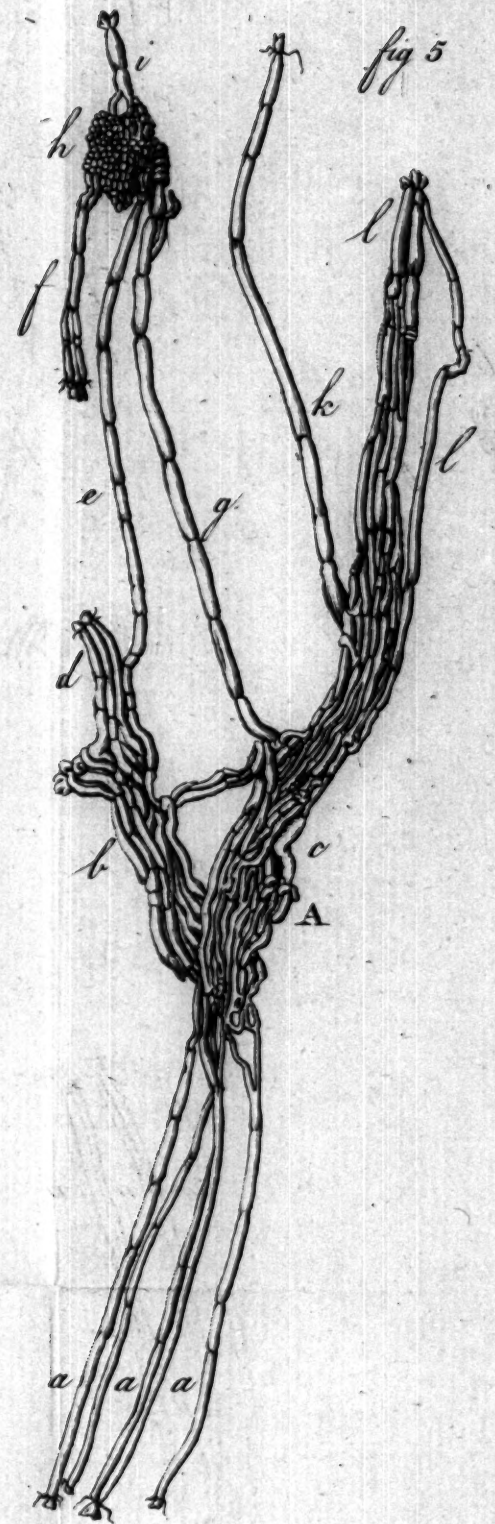
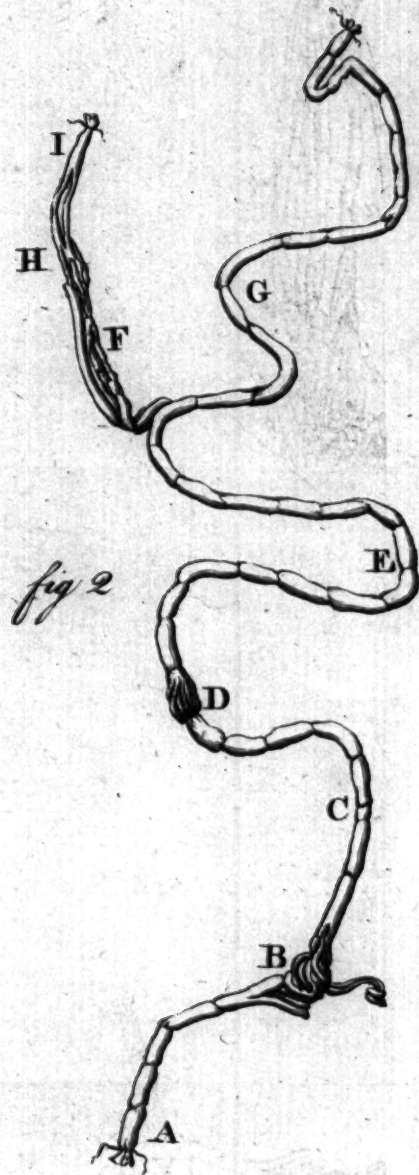
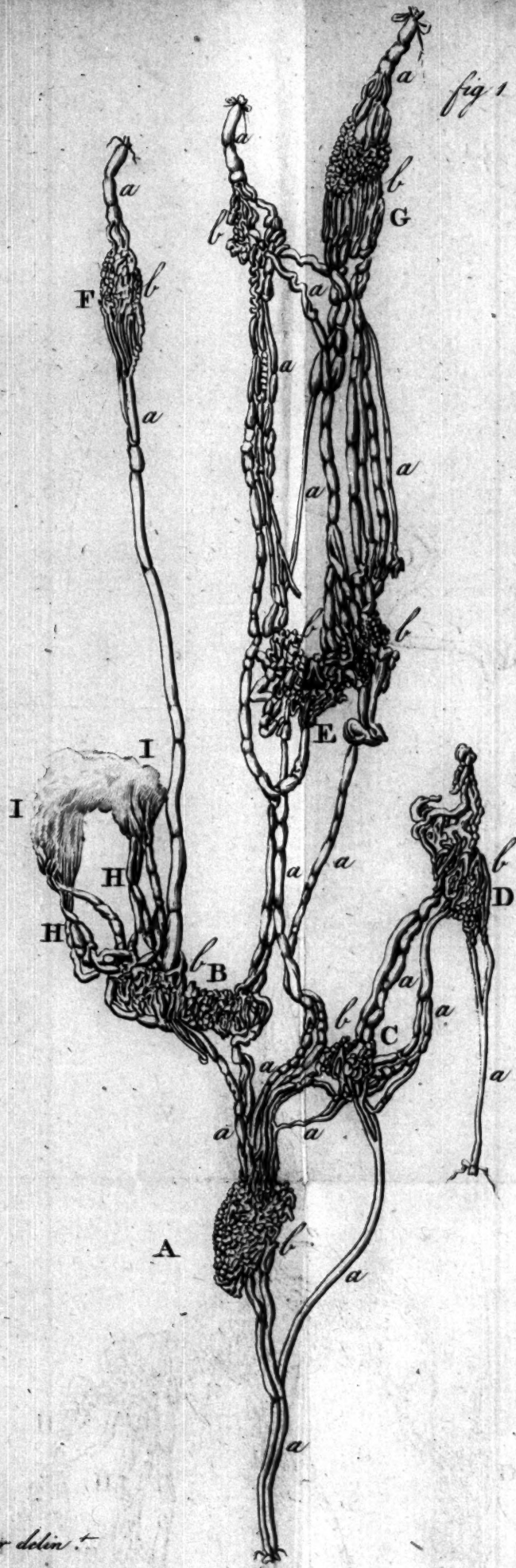
b, b, b, The intestine.

c, The artery.

d, The vein.

e, The lacteals surrounding the artery and vein,

A, A



Description of the Plates.

A, A mesh of the mesentery on which a plexus of lacteal vessels are delineated.

PLATE IV.

Fig. 1. Exhibits the chest of a still-born child, opened to shew the situation of the Thymus Gland.

a, a, a, a, The skin, muscles, and ends of the ribs, the sternum and cartilaginous part of the ribs being removed.

b, b, b, b, The edge of the diaphragm.

c, c, The right and left lung.

d, The pericardium.

e, The heart.

f, Part of the first bone of the sternum.

g, g, g, The Thymus Gland.

Fig. 2. Exhibits the size, and figure, of the vesicles of the human blood; as they appeared in the microscope, when viewed through a lens the $\frac{1}{23}$ of an inch focus. In which the solid central particle, as formerly described, is seen distinctly in the centre of each vesicle.

Fig.

Description of the Plates.

Fig. 3. Represents the size and figure of the particles found in a Lymphatic Gland, taken from the human body, as they appeared, viewed by a strong sun light, through the same lens used in the former experiments.

Fig. 4. Represents a portion of a Lymphatic Gland from the human subject greatly magnified, in which the cells of the Lymphatic Gland are shewn.

Fig. 5. The size and figure of the vesicles of the blood, taken from a common fowl.

Fig. 6. Exhibits the size and form of particles, taken from a Lymphatic Gland, found on the neck of the fowl whose blood is expressed Fig. 5.

Note. All the Experiments were made by a clear day light, and the objects viewed through the same lens, viz. $\frac{1}{21}$ of an inch focus. Except Plate IV. Fig. 4. which was examined with a lens the $\frac{1}{36}$ of an inch focus.



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